REPTILES OF THE PACIFIC WORLD

THE PACIFIC WORLD SERIES

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REPTILES OF THE PACIFIC WORLD

Arthur Loveridge

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Foreword

THIS book is one of a series describing the natural history and peoples of the Pacific Ocean and of its innumerable islands, large and small. The basin of this great ocean extends approximately halfway around the earth. Some of the islands, including most of the larger ones, that lie in this vast body of water owe their origins to the nearby continents; such islands were in earlier times actually a part of their neighboring continents. In other cases the islands arose by powerful geologic upthrusts, including volcanic eruptions, from the very bed of the ocean itself. Because of these different origins, the living things found upon the islands are of infinite variety and interest. This holds true not only of mammals, birds, insects and plant life dealt with in other books of this series, but also of reptiles and amphibians described in this volume.

The Pacific World Series has been sponsored, nurtured and created by men representing nine great American educational and scientific institutions. The original impulse or idea for the preparation of the series came from the American Committee for International Wild Life Protection. This committee not only hoped but believed that a fuller understanding of the wonder and beauty of natural things by those in the Armed Services in the present great war, as well as by their families and friends at home, would create a desire to protect and conserve the natural life of the islands which, if once destroyed, can never be replaced.

In especial regard to this book on reptiles and amphibians it is hoped that the information it contains may stimulate more widespread interest in these remarkable yet frequently misunderstood forms of life. The majority of people are still influenced by the myths and legends concerning reptiles that have been handed down

from the earliest days of man's history, days in which ignorance or fear or superstition marked the "serpent" as something to be crushed under man's heel. However, many earlier civilizations held the serpent in respect as well as in awe. The serpent-gods Osiris, in Egypt, and Krishna and Indra, in India, were prominent in the religions of those countries, and were worshiped as guardians of wealth and also as sources of knowledge. The serpents that made their home in the temples of Aesculapius, the Greek god of healing, were carefully looked after and protected. Among the symbols of this divinity was a serpent coiled around a staff used today as the symbol of the medical profession. Granted that we human beings of today are more out of touch with nature than primitive mankind, it is regrettable, as far as reptiles are concerned, that we seem to have fallen heir to the bad myths concerning them rather than the favorable ones. "There's a snake—kill him!" is still the first reaction of the majority of us as we see a harmless form gliding away from us —and a stupid reaction—forgive the bluntness—when it is recognized that of all the known different kinds of snakes on this earth not more than approximately 20 per cent are poisonous. A further fact is that, except in unusual cases, a poisonous reptile will not attack unless suddenly disturbed or threatened. Fatalities from snakebite in America are as rare as deaths from lightning. This brief plea for reptile "conservation" is evoked not by sentiment but by realism, for reptiles, as well as amphibians, contribute substantially to the scheme and economy of nature, useful to man and wildlife alike.

For these and similar reasons, it is a fine thing that the author has prepared this competent and interesting book. His experience and knowledge have provided him with special qualifications for this work. In addition to the years spent at university and museums, both in England and in Africa, he has studied and collected reptiles in four continents. He has published more than 150 papers on zoological subjects, chiefly concerning reptiles and amphibians. For many years the author has been Curator of Reptiles and Amphibians at the Museum of Comparative Zoology, Harvard University.

In this book Mr. Loveridge has accomplished a wonderful presen-

tation of his subject—a most difficult task when one calls to mind the extent of the area and the great variety of living things and their habitats to be described within the limited space allotted to each of the books of this series. For this book not only provides definitive descriptions of families and species of reptiles and amphibians to be found in the Pacific area, but also, through more intimate descriptions here and there throughout the text, suggests the reasons for living of these fascinating forms of life.

FAIRFIELD OSBORN,
President, New York Zoological Society

Acknowledgments

I SHOULD like to take this opportunity to thank Mr. Fairfield Osborn for his friendly interest in this book's progress and all he has done in furthering its publication. In reading over eight of the chapters and making many helpful suggestions, Mr. Karl P. Schmidt of the Chicago Natural History Museum has given very generously of his time. Dr. Dudley Jackson of San Antonio, Texas, kindly read the chapter on "Snake Bite and First Aid Treatment," and advocated greater emphasis on the value of certain treatment. I am also grateful to my wife for reading and rereading the manuscript and proposing improvements. To Mr. John Constable, a Harvard sophomore, I am indebted for his thorough testing of the keys with preserved specimens, resulting in some simplifications or removal of ambiguities. Thanks are also due to Mr. Eugene N. Fischer for the painstaking care with which he has drawn the illustrations. The photograph appearing on the jacket is used through the courtesy of the New York Zoological Society and the endpaper map is reproduced from the one used in "Mammals of the Pacific World" by Carter, Hill and Tate. Lastly, but by no means least, I am under an obligation to that host of herpetologists and field naturalists, named in the text, on whose observations and figures I have drawn.

ARTHUR LOVERIDGE

Contents

Introduction

In brilliancy of coloring birds, butterflies, and reptiles rank high among the wonderful wild life to be found on Pacific Islands. Rare indeed must be the incurious traveler who, on seeing these creatures for the first time, can continue unheeding on his journey. On catching sight of a departing snake, or having observed the vigorous head-bobbing of bright-hued lizards, the visitor will entertain at least a fleeting wish to know something of their ways. It is for the purpose of supplying such information that this book has been written.

So numerous are the different kinds of reptiles and amphibians to be found in the vast stretches of the Pacific that justice cannot be done to all. Faced with the necessity of choosing between this and that, it seemed best to deal more fully with the species occurring west of New Guinea from the Dutch East Indies to Japan, yet not neglecting the others. The more abundant or conspicuous forms have been selected for detailed treatment, and their temperament, breeding habits, favorite food, nature of enemies and methods of defense described.

Many of these habits are so strange and interesting, at least to those imbued with a love of wild things, that even reading about them should prove some consolation. For not all of us will be privileged to sail the blue waters of the great ocean, visit its palm-fringed islands, or penetrate their forest-clad heights.

Some will claim that undoubted advantages accrue from acquiring knowledge without stirring from one's armchair. The reader can supplement his impressions by a visit to the zoo, and is not faced with the necessity of making quick decisions as to whether a snake is, or is not, poisonous. For limited areas the recognition of venomous species is

not so difficult as appears at first sight. In some cases a little judicious collecting may prove necessary before familiarity can be achieved.

Natives are often eager to bring in reptiles for a cent or so. Do not, by offering fancy prices, become the instigator of wholesale killing. Science is not furthered by extermination. Remember those who will come after you and do not start inflation by too lavish use of money. Creatures which seem strange and intriguing to a newcomer may be easily found by an aborigine conversant with their habits. Insist from the outset that only undamaged specimens will be accepted and you will be saved much future trouble. The first offerings which an untrained native is likely to bring you are the big, showy, or common species. Large specimens, while requiring more preservative, usually exhibit little that is not to be seen in young individuals. In general, it is the smaller species that are least known and the most interesting. Many undescribed forms of Pacific reptiles await a discoverer; it may be you!

1

Island Reptiles and How They Got There

OUTSIDE of the inhospitable Aleutians, which are too cold for reptiles and amphibians, there are but few islands in the vast Pacific on which some form or other of these cold-blooded vertebrates has not become established. For their presence on the more remote islands we can invoke human agency as the factor aiding distribution. If we exclude toads intentionally introduced by modern man, and a burrowing blind-snake, we find that such islands harbor only two terrestrial types—geckos and skinks—both of which, together with their eggs in some cases, are especially likely to be transported by palm-thatched canoes carrying supplies of native produce.

The larger islands, and those lying near the main land masses of South America, Australia, or Asia, are richly supplied with reptile and amphibian life. So much so, indeed, that there are few situations which they have not successfully invaded. Some enjoy basking in the hottest sunshine of arid lowlands; others, which cannot tolerate high temperatures, favor the cool wet forests capping the mountains. Trees and shrubs are the chosen habitat of many, including certain lizards and snakes that have attempted mastery of the air by gliding. Some forms are burrowing and rarely appear above ground except during showers. A few are found only in association with rocks among crevices of which they find protection. Pools, streams, and rivers have induced adaptations to an aquatic life for many snakes and lizards besides the crocodiles, terrapins, and frogs which one usually associates with a lacustrine life. Even the ocean itself has become home for the venomous sea-snakes and great marine turtles. Nor has it proved a barrier to the journeys of at least one lizard and

monstrous crocodile, but long immersion in salt water is apparently fatal to the vast majority of frogs and toads.

Though the ocean has been no barrier to a few species, the thoughtful traveler who lands on an island and discovers it teeming with reptile life, is likely to find himself wondering when and how the ancestors of these reptiles got there, and whence they came. It is axiomatic that no natural group of animals could have originated in place or time at more than one spot, or in more than one geological era. Migration carried them to new environments where they were subjected to climatic changes which had to be overcome if the immigrants were to survive. Many perished, but the more adaptable varied to meet the new conditions. These virile forms frequently developed at the expense of their "ancestors," which in some instances survived only in habitats where they were not subjected to keen competition.

A careful study of Pacific island faunas usually reveals that the species occurring on islands close to the Asiatic mainland are, for the most part, identical with the species living on the adjacent continent. This suggests that the separation of the island from the mainland took place at a relatively recent date, geologically speaking. Some islands which are separated today were formerly united when the sea was only a few hundred feet shallower. The increase in depth may be attributed to the extensive melting of vast accumulations of ice towards the close of the last glacial period. Subsidence due to volcanic action is responsible for the isolation of certain islands, and upheavals due to the same force have given us volcanic islands like the Galápagos.

While Sakhalin and the main Japanese islands have many reptiles and amphibians common to the Asiatic mainland, the Luchus offer ample evidence of longer separation by the large number of species found there which have not been encountered elsewhere and may be considered as peculiar to the group. One or two genera of reptiles appear to have spread from the Luchus via Formosa to the Philippines, but the overwhelming majority of Filipino reptiles and amphibians seem to have reached those islands by way of Borneo. Some

genera apparently got no farther than Borneo, but their presence in the Philippines may be revealed by more extensive collecting, even on Luzon much remains to be done in the more remote regions.

As one proceeds eastward along the chain of islands known as the Dutch East Indies, the species which are common to the Asiatic mainland become fewer and fewer. It does not require much imagination to visualize this chain of islands as forming a bridge which linked Asia with New Guinea, when Sumatra and Java were merely extensions of the Malay Peninsula. But in very early times, many millions of years ago in the Age of Reptiles, subsidence, or some other factor, caused a gap in the bridge just west of New Guinea. This has proved a barrier to further dispersal which has remained very effective down through the ages. It is even claimed that the deep oceans west of New Guinea have proved an obstacle to the spread of many species of sea-snake.

We know that this interruption must have occurred before the development of the higher mammals, for the mammals of Australia (apart from the bats that flew there, a few rats that may have made the journey on flotsam, and the dingo wild dog accompanying primitive man) consist of pouched mammals like the kangaroo and its diversified relations, and the still more primitive egg-laying echidnas and platypus. As for reptiles, a glance at the distributional chart (p. 244) will show that land tortoises, true lizards, "glass-snakes," cylinder-snakes, vipers, pit-vipers, worm-like amphibia, toads, toad-frogs, disk-tongued frogs and rhacophorid tree-frogs all failed to make the journey, or if they did, failed to survive.

On the other hand, one finds in New Guinea such creatures as snapping turtles and long-necked water-tortoises, hylid tree- and southern-frogs, none of which have representatives on the wrecked Sumatra-Timor "bridge." As a matter of fact, their next of kin are in South America, so their presence in New Guinea was formerly thought to lend support to a theory that Sahul Land (New Guinea + Australia in the days when they formed one continent) was at one time connected with South America. A more probable explanation is that both regions were populated from northern

sources, and the ancestral links disappeared owing to adverse climatic changes or the competition of more virile species.

Whatever the explanation, the fact remains that New Guinea, when better known, is likely to provide many zoological surprises. Already more than a score of peculiar frogs have been discovered there which are to be found nowhere else, their differentiation due rather to the stimulus of unusual tropical habitats than to geographical isolation. At the same time there are sufficient species of reptiles and frogs common to both New Guinea and Australia to show that the separation of the world's second largest island from the adjacent mainland is of relatively recent date.

Not so the separation of the Solomons lying to the east of New Guinea, for many of its frogs, lizards, and snakes are sharply distinct from the corresponding forms in New Guinea, although they show relationship to them. Though scores of islands contribute to the Solomons group, the reptile life appears substantially uniform, indicating that the islands of today formed one unit long after the separation from New Guinea.

Continuing southeast to the New Hebrides and New Caledonia, we find both mammals and frogs missing except for recent human introductions like that of the golden frog, a common Australian species. There are, of course, both marine turtles and venomous sea-snakes around the coasts, but land snakes are restricted to two species of small boas which have a wide distribution in this region, possibly to be explained by the fact that one of these boas has been found swimming in the ocean. There is also a little burrowing blind-snake found only on the Loyalties. New Caledonia is rich only in geckos and skinks, some belonging to widespread forms, others as yet known only from a single island or group of islands.

Still moving in a southeasterly direction, we come to the Fijis, easterly outpost of Melanesia, yet presenting some anomalies. Former connection with the Australian region is shown by the presence of an elapid snake, though of a species and genus peculiar to the Fijis. Besides this venomous reptile there are the two boas, already noted on New Caledonia, and a burrowing blind-snake. Some of the nu-

merous geckos and skinks which occur all along the route from New Guinea reach the Fijis but go no further. The reported occurrence of Godeffroy's anglehead, an agamid lizard common on New Britain, is based on an old and questionable record. Strangest of all is the presence of a tree-climbing iguana. The occurrence of this banded iguana, related to forms found in tropical America though generically distinct, poses some problems for those interested in distribution. The Fijis are also the last outpost of amphibia in the eastern Pacific, if we exclude intentional introductions of recent date. The two kinds of Fijian frogs are eaten by the natives, according to Dr. William Mann, who tells us that, like all things edible, they are carried from island to island by the Fijians. Both species are restricted to the Fijis though they have close relatives in the Solomons.

In New Zealand also there are only two species of frogs (except for a human introduction); but New Zealand lies more than 1,000 miles to the south of the Fijis, so her frogs are very different. The Fijian frogs are members of the world-wide modern family to which the common North American leopard and bullfrog are accredited. The New Zealand species belong to a very ancient family comprised of two genera, one of which is confined to the western United States. The strangest thing about these New Zealand frogs is that, though tail-less, each retains tail-wagging muscles. Despite the paucity of its reptile life, New Zealand has other attractions for students of the group. On islands off her coast there lives the lizard-like tuatara, sole survivor of a whole order of reptiles which flourished in Triassic times. These oddities testify to the centuries of isolation to which New Zealand has been subjected, cut off before mammals had a chance to invade her, for apart from winged bats there are no native mammals. Nor are there any snakes—only skinks and geckos, and the latter are said to be unique in giving birth to living young instead of laying eggs as do the other geckos scattered over the face of the globe.

In all probability it is this egg-laying habit that is chiefly responsible for the present distribution of four species of gecko found on so many of the scattered islands of Polynesia. Geckos attach their hard-

shelled eggs to bark, leaves, or any convenient object. So we come back to where we started, and invoke canoe transport for gecko eggs as well as for the three beach-dwelling skinks of Polynesia. What is more likely than that a skink, perhaps in search of a better basking place, perhaps pursuing flies attracted by fishy odors, should climb into a canoe drawn up above high-water mark. Upon approach of the owner, laden with garden produce or barter goods, the reptile would naturally seek concealment and thus become an unintentional stowaway. No other explanation appears adequate to account for the distribution of these lizards among the scattered islands of Polynesia.

On sailing east from the Marquesas, which are about the most easterly of the Polynesian islands, one has to cross 3,000 miles of Pacific Ocean before coming to the Galápagos, some 600 miles from the coast of Ecuador. As might be supposed, therefore, the affinities of Galápagos reptiles (there are no amphibians) lie with South American species, certainly not with any of those encountered from Japan to the Marquesas. The famous giant tortoises, the few snakes, the geckos and the smaller iguanids, all belong to genera found on the mainland. Only the genera of the big land and marine iguanas apparently originated right on the Galápagos Islands, as have all species, for they differ from their mainland relatives.

General agreement as to the mainland relationship, however, is in no sense an explanation as to how reptiles reached these remote islands. Some have suggested a former connection with Central America along a causeway now lying submerged at a depth of 6,000 feet. Had such a bridge existed, it is reasonable to suppose that at least some frogs or toads would have made the journey; their absence militates against acceptance of the theory. Alternatively, some hold that the ancestors of the Galápagos reptiles reached the islands fortuitously among mats of tropical vegetation entangled about trees swept out to sea by rivers in spate, and carried on by ocean currents.

2

What Is a Reptile?—The Tuatara

It is scarcely more than a century since the confusion attending the separation of reptiles and amphibians was solved satisfactorily by the recognition that these back-boned animals formed two distinct classes of the VERTEBRATA.

As attested by the abundant remains of Dinosaurs, Stegocephalians, and other orders with even less familiar names, in bygone ages both groups played a more prominent role than at present. It is, however, only with the relatively small surviving species that we are now concerned.

EXTERNAL CHARACTERS

The name REPTILIA was given to those present-day species with a dry skin usually covered by scales or shields, and whose young on hatching, or at birth, are lung-breathers substantially resembling their parents. Their name is derived from the Latin *reptilis*, in reference to the creeping habits of some forms.

On the other hand, those kinds with skin more frequently moist and devoid of external scales (with the exception of a few species of burrowing, worm-like cæcilians), the vast majority of which undergo a change within the egg, or upon hatching, from an aquatic gill-bearing tadpole to a lung-breathing type, are called AMPHIBIA. The origin of this name is a Greek word (*amphi* + *bios*) meaning "double life," in allusion to the earlier stages of most species being passed in water and their adulthood, in most cases, on land.

Such qualified definitions may not sound too satisfactory, but in practice they work well because the actual exceptions are relatively few. The fundamental differences between the two classes are more

sharply defined, being structural. To cite differences in skeleton, heart, lungs, or kidneys, however, would afford no help to the man in the field who wishes to know whether some creature is a reptile or an amphibian!

With their temperatures largely dependent on that of the atmosphere or water in which they may happen to be, reptiles and amphibians are sometimes referred to as cold-blooded vertebrates, a title which they share with fish. Though most fish are gill-breathers, the famous lung fish are at times dependent on their lungs so that the sole character separating all jawed fish from all amphibians is the absence of fin rays in the latter.

From the warm-blooded vertebrates—birds and mammals—reptiles and amphibians may be recognized by the absence of feathers or hair, the so-called "hairy frog" of West Africa owing its popular name to filaments of skin which have only a superficial resemblance to hair. Contrariwise, the "hairless rat" of East Africa has whiskers and a few hairs, though one might be hard put to find them in the adults of some marine mammals.

Omitting for the moment the rather iguana-like tuatara (fig. 3), found only on certain islands in the Bay of Plenty, New Zealand, the remaining three orders of living reptiles may be recognized by external features without much difficulty. One of these orders (SQUAMATA) is comprised of lizards (SAURIA or LACERTILIA) and snakes (SERPENTES or OPHIDIA), and these two suborders are not so readily distinguished as most people suppose. The difficulty centers about some burrowing lizards which have lost both limbs and movable eyelids, the latter having become transparent and fixed over the delicate eye, protecting it as does a watch-glass the face of a watch.

When in doubt about the order to which some reptile belongs, the student should find assistance from the following key in reaching a decision.

KEY TO AID IN THE RECOGNITION OF THE MAJOR GROUPS[1]

1.	Body enveloped in a more or less fully developed bony shell, consisting of an upper (carapace) and lower (plastron) portion (figs. 5, 6)	turtles and tortoises (TESTUDINATA)
	Body not enveloped in a bony shell	2
2.	Anal opening longitudinal; body more or less strongly protected by horny shields which on the back, and sometimes on the belly, overlie bony plates (fig. 1)	garial and crocodiles (LORICATA)
	Anal opening transverse; body protected chiefly by scales or granules	3 scaled reptiles (SQUAMATA)
3.	The 2 halves of the lower jaw united by a suture; *most* species have a movable eyelid and 4 limbs (fig. 2)	lizards and chameleons (SAURIA)
	The 2 halves of the lower jaw united by a more or less elastic ligament; eyelids transparent, immovable; no limbs (fig. 3)	snakes (SERPENTES)

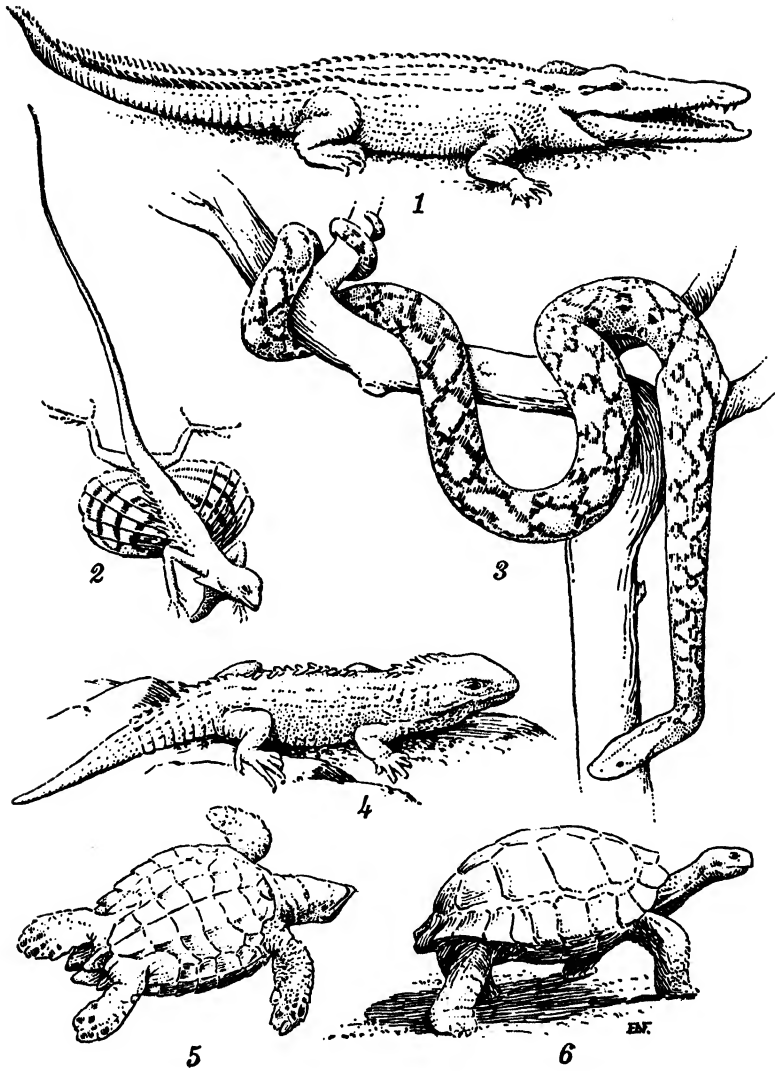
[1] Omitting the tuatara (RHYNCHOCEPHALIA) found only in New Zealand.

PLATE I

FIG.

1. Estuarine crocodile (20 feet) showing back protected by horny shields. Order LORICATA.
2. "Flying" lizard (8 inches) of Sarawak, representing Suborder SAURIA.
3. Reticulated python (32 feet) of East Indies, representing Suborder SERPENTES.
4. Tuatara (30 inches) of New Zealand; only living representative of Order RHYNCHOCEPHALIA.
5. Hawksbill turtle (shell length 3 feet) showing under-shell or plastron. Order TESTUDINATA.
6. Galápagos tortoise (shell length 4 feet) showing upper-shell or carapace. Order TESTUDINATA.

PLATE I



TUATARAS

The tuatara (fig. 3), sole survivor of its ancient order RHYNCHOCEPHALIA, has been omitted from the key, as it is highly improbable that anyone will have a tuatara to identify. It is to be found only on some almost inaccessible islands in the Bay of Plenty, New Zealand. Another reason for leaving this reptile out of the key is on account of the difficulty of distinguishing it from a lizard by any external feature. Anatomically it is distinct enough and is in fact as nearly related to the turtles as to lizards. One characteristic which it shares with some lizards, though much better developed in the tuatara, is its "third eye."

This pineal eye, complete with lens and pigmented retina, is situated beneath a light-colored scale on the crown of the head and above a hole in the skull. Through this opening passes the nerve which connects the pineal eye with the ridiculously small pea-sized brain. Presumably the eye once served to warn the tuatara of the approach of an enemy above; today it may be able to distinguish between light and darkness, but that is all.

Twenty (rarely 30) inches in length, these olive or yellowish brown reptiles carry a prominent serrated crest of enlarged scales along the back and tail. It is this crest which has gained for the creature its name, for tuatara in Maori means "having spines." When a tuatara raises its head to look about, its large, quiet eyes impart a dignified mien that is not in keeping with its reputed dullness and sluggish ways. Progress is normally a slow crawl, with belly and tail trailing along the ground. Only when chased, or chasing its prey, does a tuatara trouble to raise its body, but wearying after a few feet, it soon comes to a stop. Jumping is quite beyond a tuatara's powers.

However, tuataras can dig, for each excavates its own burrow among the rocks, wind-blown brush, and coarse grass covering its island home. The entrance to one of these burrows is 4 or 5 inches in diameter and the descending, then ascending, passage about 2 or 3 feet in length. The terminal chamber, about 6 inches high, may be as

much as a foot wide and 18 inches long, and is lined with grass and leaves. One side of this burrow is occupied by a little gray and white petrel, with its single egg or fluffy nestling. Curiously enough, the tuatara does not molest the bird, though it is intolerant of any other intruder.

The reptile likes to lie with its head near the entrance of the chamber. If a hand or stick is introduced, it will be bitten just as vigorously as if it were another tuatara, for they are quarrelsome creatures. Their principal food consists of a big, wingless, locust-like insect, but beetles, spiders, and other small creatures are also taken. Captive tuataras show strange preferences; one will refuse all food but minnows, while another will take lizards, prey that they are hardly likely to be able to get in their wild state. As pets they are uninteresting but live on and on for as much as twenty-eight years. Their inch-long, hard-shelled eggs are laid during the southern summer, and though the embryos appear to be ready for hatching in six months, they do not hatch for a whole year.

3

Turtles, Terrapins, and Tortoises

WITH the solitary exception of a paddle-limbed freshwater turtle found only in the Fly River of New Guinea, the possession of paddle-like forelimbs or flippers, with at most a couple of claws on each, immediately distinguishes the sea-going turtles from their freshwater or land-dwelling relatives. These latter have well-developed, clawed limbs, with or without webbing in the case of the aquatic species, more or less club-footed in the true terrestrial tortoises.

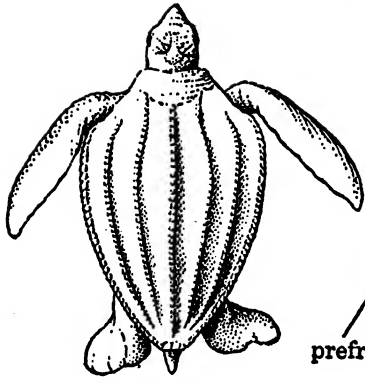
Other adaptations of turtles to a marine existence are to be seen in their heart-shaped shells, depressed and streamlined for rapid progress through the water. The nostrils are so placed that they can be raised easily above the surface for breathing, then closed by a fleshy valve as the turtle submerges. The head cannot be entirely withdrawn inside the shell.

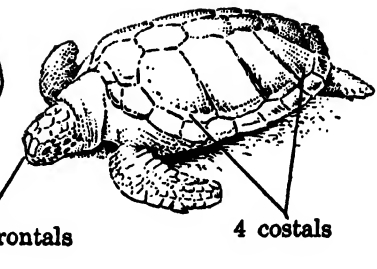
The five species inhabiting the Pacific may be distinguished as shown on page 15.

LEATHERBACK

Though living turtles do not attain the huge size of certain fossil species, nevertheless they are quite substantial as regards both size and weight. Chief among them in this respect is the leatherback (fig. 7), so named on account of the blackish or brownish leathery skin covering the unusually constructed shell. This shell differs from those of all other turtles in being composed of a mosaic of small bones. Its seven lengthwise ridges and fancied resemblance to a harp has led some writers to call it the harp turtle. It is also known as the trunk turtle and luth. Eight feet in length from snout to end of shell, and weighing

PLATE II





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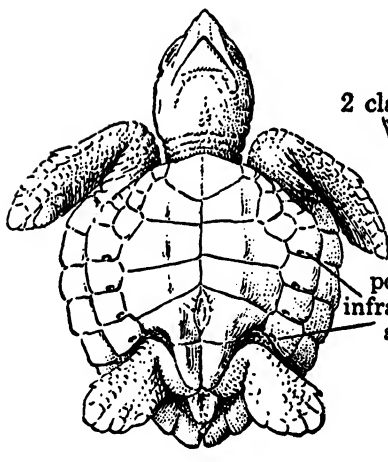
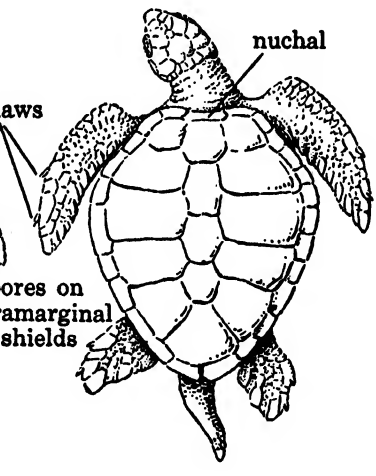




9 10

FIG.

7. Leatherback (shell length 8 feet) showing seven ridges on shell.
8. Green turtle (shell length 4 feet) showing prefrontals and claw.
9. Young gray-olive loggerhead (adult shell length 2½ feet); the heads of young turtles are disproportionately large.
10. Red-brown loggerhead (shell length 3½ feet) showing nuchal shield.

Key to the Sea Turtles of the Pacific

1. Upper shell covered with smooth skin showing 7 prominent longitudinal ridges; limbs clawless (fig. 7) ..... leatherback (*Dermochelys coriacea*)

   Upper shell covered with smooth horny shields without ridges except in young loggerheads and hawksbills which may have 3; limbs with 1 or 2 claws 2

2. Upper shell with 5 or more pairs of costal shields of which the foremost pair is normally in contact with the nuchal (fig. 10) 3

   Upper shell with 4 pairs of costal shields of which the foremost pair is separated from the nuchal shield 4

3. Upper shell normally with 6 to 9 (rarely 4 or 5) pairs of costal shields; bridge on either side of lower shell with 4 enlarged inframarginal shields, each with or without a pore (fig. 9) ..... gray-olive loggerhead (*Lepidochelys olivacea*)

   Upper shell normally with only 5 pairs of costal shields; bridge on either side of lower shell with 3 enlarged inframarginal shields without pores ..... red-brown loggerhead (*Caretta caretta*)

4. Jaws not hooked; 2 prefrontal shields on head (fig. 8); shields of upper shell not overlapping (except in very young turtles); usually a single claw on each limb ..... green turtle (*Chelonia mydas*)

5. Jaws hooked; 4 prefrontal shields on head; shields of upper shell strongly overlapping (except in very young or very old turtles[1]); usually 2 claws on each limb .... hawksbill (*Eretmochelys imbricata*)

[1] Roughly those with shell under 5 inches or over 15 inches.

upward of 1,450 pounds, this monster ranges widely in tropical seas. Sometimes it wanders into colder waters, having been taken as far north as Vancouver Island and in the British Isles.

The only circumstances that can induce these great turtles to leave the deep waters is the urge to lay their eggs. This impulse takes place in the "spring" (March to June) in points as far apart as the West Indies and Ceylon. At night the female crawls out on some suitable sandy beach and searches for a satisfactory spot in which to dig. The whole process, as observed in Ceylon, has been described in detail by P. E. P. Deraniyagala.

He watched a leathery turtle zigzag up the beach, testing the sand here and there with her powerful flippers until she was entirely plastered with sand, except for the eyes which were kept moist by a flow of tears. After forming a preliminary crater by side-to-side motions of her shell, the leatherback appeared to anchor herself with the front flippers while using her hind ones to dig persistently until she could reach no deeper. That is to say when the hole, together with its surrounding crater, was about a yard in depth. The nest hole is deeper than that of any other species of turtle.

Though reputedly cautious when approaching land, the turtle showed absolute indifference to lights, noise, or Dr. Deraniyagala's presence once she began egg laying. With body sloping into the pit at an angle of about 35 degrees, the laying began, eggs being deposited in batches of two or three at a time. Her breathing was rather noisy during the process and she kept moving her head up and down with the exertion. No sooner were the eggs all laid than the turtle started to cover them by placing flipperful after flipperful of sand gently upon them. Once they were well covered, the sand was flung in with greater rapidity. The final phase consisted in breaking down the crater. This the leatherback accomplished by rapid sidewise motions of her hindquarters and tail, though the shell itself remained motionless. Then, rotating on her lower shell, she began to churn up the beach surrounding the nest, flinging up great showers of sand and even using her head to demolish any outstanding ridges.

Her task accomplished, the exhausted turtle turned seaward again.

Wearily heaving her great bulk over the sand, she paused every few feet to rest and blow. Once the turtle is out of its element, the entire weight of its shell presses upon its chest, making breathing difficult—so difficult, in fact, that in course of time a struggling turtle will suffocate unless turned upon its back. Gradually recovering strength, Deraniyagala's leatherback was able to increase her efforts to ten and even fifteen shuffles before taking a rest. Finally, reaching the surf, she paused for the last time, waiting until the waves should wash her in. But the breakers were rough that night and she failed to pass them at the first attempt. Next time she hugged the beach as the wave broke over her, then, slipping beneath it, disappeared from sight.

Even without the elements of storm and shower which in the course of a day or two would obliterate all traces of her activities, the mother turtle so effectually concealed the spot where she had buried her eggs that when Deraniyagala and his two companions turned back, they dug with their hands for an hour without finding anything. On another occasion he had surprised a large monitor lizard that had already excavated three holes to no purpose, busily engaged in digging for a leatherback's eggs. It may be supposed that such lizards are normally guided in their search by scent. If so, it is likely that they would be thwarted by the powerful fishy odor emitted by a leatherback when laying, for the pungent smell pervaded the entire area of disturbed sand.

From 90 to 150 soft-shelled spherical eggs, about 2 inches in diameter, are laid at one time. Like those of most reptiles, they are usually white, but occasionally a nestful may be found flecked with green. They take nearly two months to hatch, and this may be prolonged a week or two by vagaries of the weather, or by transportation to a new site for observation. In several nests twin turtles were found within a single egg.

Immediately upon hatching, the little luth makes for the open sea, never again to leave deep water except by accident or when, as a mature female, she may return to the beach. Deraniyagala, who kept some hatchlings in an aquarium, remarks on the speed and ease with which they swim by long downward strokes of their relatively huge

forelimbs. They entirely failed to comprehend the limitations of captivity and persisted in swimming against the glass sides of their tank, injuring their snouts and flippers. Young of other species of marine turtles seem to have more intelligence, for they soon adapt themselves to aquarium life. Unfortunately, no zoo has as yet been successful in keeping an adult leatherback alive for more than three weeks.

Deraniyagala fed his youngsters on finely chopped fish, though it may be doubted whether this was their natural food at so tender an age. In dissected adults were found fish, jellyfish, mollusks, shrimp-like "sand fleas," and small quantities of seaweed, the latter possibly an accidental introduction. The adults are very oily creatures, and in some places this oil is used for varnishing canoes. The dark coarse flesh has an unpleasant flavor and, though generally regarded as inedible, is sometimes used in a curry.

RED–BROWN LOGGERHEAD

The red-brown or Atlantic loggerhead (fig. 10) is noted for its enormous head which may be as much as 11 inches long in an old turtle. Such large specimens are rarely met with, though one example has been recorded measuring as much as 9 feet across from tip to tip of its outstretched flippers, and weighing 850 pounds. Old loggerheads are brown to reddish brown above, yellowish to pale orange below, while their young range from blackish to dark brown above and white beneath. Assuming that the Atlantic loggerhead is identical with that found in the Indian Ocean, then its very extensive range includes New York and the Dutch East Indies.

It is known to nest on such widely scattered points as Loggerhead Key in Florida, Australia's Great Barrier Reef, and Ceylon. The nesting habits have been described in considerable detail but need not be repeated here as they do not differ materially from those recorded for the leatherback. In one instance a 4-foot-long trench was dug to a depth of 10 inches by alternate use of the right and left hind flippers. Once egg-laying had begun, the loggerhead displayed the same indifference to interference that was noted in the leatherback.

She did not become so tired, and on her way down the beach appeared to carry with little effort the observer, weighing 165 pounds, who stood upon her back.

She reached the ocean just forty-two minutes after she had first emerged from it. This individual made an almost straight track to and from the ocean, clearly betraying the location of the nest though not the precise spot where the eggs were buried. S. O. Mast, who made these observations, carefully noted the exact position of the nest at the time of laying, yet when he returned he had considerable difficulty in finding the eggs.

The eggs vary somewhat in size but are about 1¾ inches in diameter. The number of eggs per nest ranges from 60 to 152. It has been suggested, but without proof, that the lower figure represents a second or third laying by one individual in the same season—May to August. As the eggs are delicious eating, fishermen in most countries supplement their other activities by searching for the nests.

Incubation occupies about two months, then the hatchling struggles up through the sand to daylight. Once on the surface, its instinctive urge to travel downhill eventually lands it in the ocean. There its diet consists of "loggerhead sponge," Portuguese man-of-war, fish and crabs, but chiefly mollusks. Even stout conch shells are easily crushed by the powerful jaws of a big loggerhead.

Gentle when young, loggerheads are apt to become irascible and vicious on reaching maturity. Growth in captivity may be slow or rapid. In its first three years one turtle attained a weight of 42 pounds, while its shell was almost 21 inches in length. During the succeeding eighteen months it nearly doubled in weight by turning the scales at 81½ pounds. Obviously they thrive in captivity, as one lived in the Lisbon Aquarium for thirty-three years until it succumbed during a period of exceptionally hot weather. Old loggerheads are not much esteemed as food, for their flesh is somewhat coarse and dark, with a distinct resemblance to beef in both color and flavor.

GRAY-OLIVE LOGGERHEAD

For over a century it was not generally realized that two species of loggerhead existed. The oversight was due largely to the fact that both species range through the Atlantic and Pacific. The so-called Pacific or gray-olive loggerhead (fig. 9) is also common along the West African coast. Apparently never attaining the dimensions of the red-brown loggerhead, the gray-olive species measures about 3 feet 2 inches from snout to end of shell, the shell alone being 31 inches long. When hatched, the young are sooty black above but gradually change to dark gray and then to olive-green as they grow. Below they vary from greenish white to pale yellow, with pinkish inframarginal pores.

In the main the habits of the gray-olive species are similar to those of its larger relative, but apparently it prefers to nest on sandbars at river mouths. Deraniyagala suggests that the finer sand found in such a location may influence its choice, or it may be on account of the greater dilution of the brine, for salt water exerts a coagulating action on the yolk of turtle eggs. Whatever the reason, the nests of this turtle are more readily found than those of the preceding species, for they are dug in the shelter of a *Pandanus* shrub at the apex of a Λ–shaped mark formed by the turtle's trails to and from the ocean.

There, in a foot-deep trench, from 90 to 135 eggs may be dropped. The eggs vary from 1½ to 1¾ inches in diameter. When laid they are surrounded by a very sticky mucus which tends to cement them firmly together. They are, of course, good to eat if found in time; the laying season for this species extends from September to January. Normally incubation takes fifty days, but unfavorable weather conditions may delay it by ten days or more.

Deraniyagala discovered that captive hatchlings were apt to turn cannibalistic when hungry and bite pieces from each others' flippers. Sometimes at feeding time several turtlets might be gathered about a delectable morsel when a late arrival, failing to break through the circle, would seize the flipper of a more fortunate comrade and hang on with bulldog tenacity while the victim swam wildly about in an

effort to shake off its opponent. Fish, meat, and bread were taken, but the species appears to be largely vegetarian, though a young pearl oyster or a "sand dollar" may be found among the seaweeds that fill an adult's stomach.

GREEN TURTLE

Superficially similar as a loggerhead and green turtle (fig. 8) may appear to the uninitiated, differences are immediately apparent when steaks of both are served at table. It is the succulence of its flesh that has earned the name of "edible turtle" for the green species. The title "green" is derived from the color of its fatty tissues, which form an ingredient of those soups so long associated with aldermanic banquets.

The shell is olive or brown above, more or less blotched or mottled with yellow; below the color ranges from pale yellow to lemon. While the shell of a large green turtle may be almost 4 feet in length, 3 feet is now nearer the average for an adult. Similarly, though a turtle once taken at Key West, Florida, weighed 700 pounds, those appearing in the American markets today range from 75 to 150 pounds.

Wide-ranging like its allies, the green turtle is usually found within 35 degrees north or south of the equator. Wanderers, however, may get carried in the Gulf Stream to more northerly points, for they have been recorded from the vicinity of Long Island and along the Massachusetts shore. On the west coast they occasionally visit the bays of San Diego County.

An extensive circum-tropical distribution does not necessarily imply that these turtles are great wanderers. On the contrary, some evidence is available to show that the young, at least, frequently remain in the general region where they were hatched. Hatchlings tagged in the West Indies were retaken within fifty miles of their point of origin. F. W. Moorhouse records that a female that landed on Heron Island, east of Australia, on two consecutive nights, though "turned" and even transported to the turtle cannery before being released, subsequently returned to her favorite nesting site.

Each female lays from two to three batches of eggs every season. The season varies according to latitude, so that green turtle nests have been recorded for every month in the year from one part of the world or another. Off western Borneo the peak season is from May to September, while in the eastern Australian region it is from October to February.

Though the site is usually well above the high-water mark, an exceptionally high tide on Heron Island destroyed many nests, for the salt water coagulated the yolk or drowned the embryos, when it did not actually wash the eggs from the nests. Off the west coast of Borneo are several islands favored by green turtles, and a survey made there by Banks in 1932 revealed that 107 eggs was the average number in 10,726 nests rifled. Two years later 16,690 nests were examined and found to have an average content of 108. In the Irrawaddy Division of Burma, F. D. Maxwell reports that 1,600,000 or more green turtle eggs are annually collected for human consumption. In size the eggs correspond to those of the gray-olive loggerhead; that is to say, they range from 1½ to 1¾ inches in diameter.

The incubation period might be expected to vary somewhat in relation to the distance from the equator, but sundry records indicate the astonishingly wide range of from forty-seven to seventy-two days. While several observers state that the young, on hatching, immediately make for the sea, another claims that the perilous journey is only undertaken after dark. Apparently this conclusion was partly based on the behavior of a hatchling which he saw struggle to the surface of the sand in daylight, then promptly rebury itself, presumably to await a more propitious hour.

As if realizing that their lives depend upon it, the hatchlings hasten seaward with a speed impossible for an adult. On Heron Island, Moorhouse observed that cats killed many of the turtlets, while crabs were seen to seize others, holding the little creature with one pincer while stripping it of its shields with the other. In some localities birds of prey carry off many hatchlings, and most of those that manage to reach the ocean fall a prey to lurking fish. Even adult turtles are not immune to attack by sharks, which bite off their flippers or even swal-

low small specimens whole. W. Beebe saw a turtle of about 50 pounds weight removed from the stomach of a 13-foot shark.

However, man is the green turtle's most relentless foe. He not only probes for the eggs but takes advantage of the mother turtle's necessity to capture breeding females by the thousand. This is accomplished at night by several men lying in wait until the turtle has progressed far enough up the beach. Then, intercepting her retreat, the men proceed to turn her over by seizing her flippers, or by using a pole; once upon her back, the turtle is helpless. Greedy hunters sometimes turn more than they can remove. When a sufficient number have been so "turned," the task of removing the turtles begins. Often this is no easy undertaking when one considers the weight of a full-grown specimen. On board ship they may be placed in tanks, but more often are laid on their backs and lashed to the decks with ropes, then covered with a few damp sacks. This method has been denounced as needlessly cruel, but defended on the grounds that the turtle would suffocate if placed right side up for any length of time.

While this is probably true, it is also a fact that on remote atolls or rock ledges of the Hawaiian and Galápagos Islands rarely visited by man, these turtles come out to bask and sleep. Clifford H. Pope has suggested that the demands on the lungs of quiescent reptiles are so much less than on those of a frightened, struggling turtle that breathing is not impeded. Apparently sleeping green turtles may be seen floating upon the placid surface of the Pacific.

In some regions the green turtle is hunted in its own element by natives in a sailing boat. On setting out, they scan the bottom of the lagoon till they detect a feeding turtle. Then one of the men, a rope tied about his waist, slips overboard and, diving down, seizes the turtle, whereupon his companions haul him and his prey to the surface. An even more ingenious method is practiced in the Torres Straits. There a cord is fastened, not to a man but about the tail of a fish (either *Echneis* or *Remora*) of the mackerel clan that commonly adheres to sharks. The fish, seeking shelter beneath the turtle, attaches itself to the lower shell by means of a powerful sucking apparatus covering the crown of its head and neck. By gently pulling on the

line, the natives tactfully coax the turtle into shallow water or to the surface where it may be harpooned.

A floating mat of turtle-grass (*Zostera*) on the surface of lagoon or bay often betrays the presence of feeding turtles to their enemies. The mat is formed by the rejected portions of the grass, for only the most tender basal part is selected by the turtles. Deraniyagala declares that under congenial conditions the turtles graze almost as continuously as do ruminants. Undoubtedly the edibility of this species is in large part due to its vegetarian diet, though in captivity they actually exhibit a preference for animal food and eagerly accept both fish and meat.

Green turtles are quite hardy in captivity, where their graceful and leisurely movements are a pleasure to watch. Some in the London Zoo's Aquarium that were less than a pound in weight when received, increased to over 50 pounds in about nine years and four months. In the New York Aquarium a green turtle from the Pacific lived happily for fifteen years.

At times the flesh of turtles is poisonous, though whether this applies to the green turtle is not clear. By inference it does in the case recorded by Sir J. E. Tennant, where 28 persons were taken ill and 18 subsequently died, after dining off a turtle at Pantura, Ceylon, in October 1840. In the Philippine fatalities of November 1917, when 14 died out of a party of 33 who partook of turtle, no species is mentioned by E. H. Taylor. As it was definitely a hawksbill's flesh that poisoned 24 persons, of whom 7 died, at Mandaitivu, Ceylon, in June 1921, perhaps all these cases are attributable to that species.

HAWKSBILL

Natives claim that the flesh of the hawksbill is dangerous only after the animal has been feeding on certain poisonous seaweeds. The flesh of this species is eaten usually by the poorer classes only and is not generally regarded as edible. According to Deraniyagala, experienced fishermen test the edibility of each turtle by first cutting up its liver and throwing it to the crows. If the birds reject these tidbits, the animal itself is regarded as inedible.

Though generally rejected as food, the hawksbill is economically second only to the green turtle in importance, though for a very different reason. Its value lies in the shields of the upper shell, which are clear yellow richly streaked and mottled with brown. Below it is light yellow. It is these overlapping shields which furnish the famous "tortoise shell" of commerce. Each turtle yields rather more than 3½ pounds of shell on the average, though as much as 10 pounds may be taken from an exceptionally large specimen. In 1909 the Philippines exported nearly 4,500 pounds of tortoise shell. On the turtle these shields often appear dull, scratched, or encrusted with barnacles, but in the hands of a skilled craftsman they soon take on a wonderful polish, and following two minutes' immersion in hot oil or water of 90 degrees C., become sufficiently plastic to be molded or welded together into any shape desired.

From this turtle's shields articles of exquisite beauty have been fashioned by both Japanese and Chinese since very early times. Wealthy Romans used tortoise shell as a veneer for furniture, and for a period of more than 600 years Italian and French workmen produced tortoise-shell objects in great variety from snuff boxes to cigarette cases. Fortunately for the turtles, rising costs of "shell" and labor have all but killed the industry and resulted in the celluloid substitutes of today. These often resemble the genuine article so closely that only "feel" and flame serve to separate the true and false, the spurious celluloid "shell" being highly inflammable. Other imitations are made of plastics or translucent horn cleverly stained.

Less than a century ago natives obtained the shell by cruel methods. Waylaying the female hawksbill when she came ashore, they bound her flippers together above a pole and so suspended her, back downward, over glowing embers until the heat caused the shields to curl and peel from the underlying bone. By such crude practice the shields were sometimes scorched or damaged. Stripped of its shields, the hapless turtle was allowed to return to the sea. This custom originated in the idea that the turtle could then grow a fresh set of shields. That under certain circumstances reproduction of shields may take place is undoubtedly true, though such shields are apt to be thin, brittle, and

with little commercial value. It is reasonable to assume that many of the turtles so treated, if they survive the shock, are likely to have had the delicate cells which give rise to the shields, injured by heat. Fortunately, wherever the industry has come under European supervision this inhuman practice has been abolished.

In Celebes, where some of the finest tortoise shell is produced, the turtle is first killed by a blow on the head, or by having its head chopped off. Then the plates are loosened by immersing the body in boiling water. The same end may be attained by burying the dead turtle in sand for a week or so until decomposition loosens the shields; however, if left too long, the shields may lose much of their translucency and markings, and consequently their value.

According to J. W. Bennett, despite annual deprivation of its shields, a hawksbill will continue to return to the same beach each year. This dubious claim is based on the statement of a Sinhalese who, in 1826, brought to Bennett a ring from a turtle which he vowed had revisited Amaidhuva Cove for thirty-two successive years since it had been first ringed by the Dutch Commandant in 1794.

The laying season is throughout the year, with September to November as the peak months in the Indian Ocean. Deraniyagala has carefully recorded the whole process as performed in Ceylon, but it does not differ essentially from that of other species except that it often takes place in daylight. From 115 to 200 eggs may be laid by one hawksbill; the eggs are almost spherical and approximately 1¾ inches in diameter. Their incubation takes about sixty days.

All the eggs of a batch hatch about the same time, the hatchlings digging themselves out in rapid succession. Upon emergence they appear to be strongly attracted by light, and crowd round a lantern. This attraction seems to leave them just as soon as they are placed in water.

In size the hawksbill is the smallest of the marine turtles, the largest known shell being a couple of inches short of 3 feet in length. Today a shell of 2 feet may be regarded as large. Though some hawksbills weigh over 60 pounds, Dr. Harold Babcock thinks that the average nowadays lies somewhere between 20 and 30 pounds. He attributes

the rarity of larger individuals to the persistent hunting which is gradually exterminating the species.

Ranging through tropical and subtropical seas from the Indian and Pacific Oceans to the Atlantic, the hawksbill even turns up from time to time as far north as Massachusetts. As individuals, their movements are rather restricted, though a wounded hawksbill bearing the broken point of an imbedded harpoon is known to have traveled twenty-five miles in two and one-half days.

The hawksbill, so named on account of its hooked beak, by means of its powerful jaws is able to break the shells of the crabs and mollusks on which it feeds. In captivity hawksbills are voracious feeders, taking seaweed and chopped fish. Generally speaking, they display a pugnacity quite unusual for a turtle; one even attacked a green turtle that shared its aquarium. Another, that was alive in the Berlin Zoological Gardens in 1936, had been there for fifteen and three-fourths years.

The numerous land and freshwater "turtles" of the Pacific have been separated into six groups or families. Before proceeding to discuss the different species, it would be well to have some idea as to which of these groups a particular "turtle" belongs.

Key to the Families of Freshwater Turtles, Terrapins, and Tortoises of the Pacific [1]

1. Upper shell covered with horny shields; snout not projecting as a soft proboscis 2

   Upper shell covered with smooth or pitted skin, without shields; snout more or less projecting as a soft proboscis 7

2. Neck hidden when head is withdrawn into shell (fig. 16) 3

[1] Ranges extending beyond the Pacific not included.

Neck fully exposed (by being bent to one side) when head is sheltering beneath shell (fig. 17) 6

3. Head moderate; tail short, not ridged above; lower shell large, protecting most of undersurface 4

Head large; tail long with 7 ridges above; lower shell small, cross-shaped, exposing much of undersurface 5

4. Hind limbs not stump-shaped, at least the foot flattened, toes usually webbed;[1] top of head covered with smooth skin or at most a few shields on its posterior part only (fig. 15); range: Japan southwest to Sumatra; east to the Moluccas ..... terrapins and hill-tortoises (EMYDIDÆ)

Hind limbs stump-shaped, cylindrical; toes not webbed; top of head entirely covered with shields (fig. 6); range: Japan south to Formosa; Borneo to Java; Celebes, Moluccas and Galápagos ..... land tortoises (TESTUDINIDÆ)

5. Range: known only from the Fly River, New Guinea ..... snapping turtle (CHELYDRIDÆ)

6. Range: freshwaters of New Guinea .. long-necked water-tortoises (CHELYDIDÆ)

7. Limbs paddle-shaped flippers with only 2 claws (fig. 18); range: known only from the Fly River, New Guinea ... pitted-shelled turtle (CARETTOCHELYDIDÆ)

[1] The exceptions being the two kinds of spiny hill-tortoises found in Borneo, Philippines, and the Dutch East Indies.

Limbs strongly webbed with 3 claws (fig. 20); range: Philippines; Dutch East Indies; Timor ..... soft-shelled turtles (TRIONYCHIDÆ)

The terrapins, as freshwater tortoises of the family EMYDIDÆ are called, form an interesting group occupying an intermediate position between the wholly aquatic and entirely terrestrial tortoises. While the majority of them are aquatic, their fondness for sunshine lures them from the water to bask on banks of streams or at the edges of ponds. Others spend most of their time on land, though usually in dampish places, and these species show a tendency to lose, or have already lost, the swimming web between their toes. Consequently, they are likely to be mistaken for true tortoises if one forgets that in true tortoises the whole of the top of the head is covered with shields.

It is well to remember that no terrapins occur in New Guinea or Australia, where their place is taken by the long-necked water-tortoises. These tortoises, when alarmed, instead of completely withdrawing their heads as would a terrapin, fold it back sidewise beneath the front edge of the shell, thus leaving one side of the neck and head exposed (fig. 17). Otherwise terrapins enjoy a distribution embracing all continents, being most numerous in North America, where one finds such species as the slider, painted turtle, box-turtle, etc. With one exception all of the fifteen species inhabiting the Pacific islands also occur on the Asiatic mainland, so this fact is omitted from the following key.

KEY TO THE TERRAPINS AND HILL-TORTOISES OF THE PACIFIC[1]

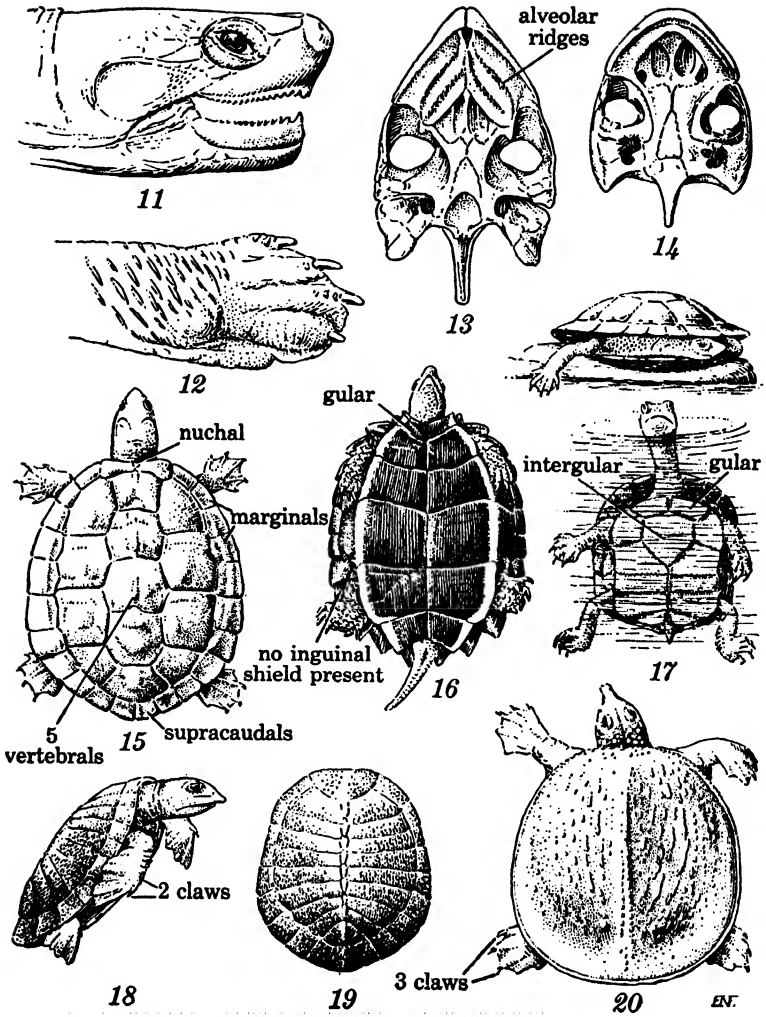
A. Species occurring south of Formosa.

1. Skin on back of head divided into scales 2

   Skin on back of head not divided into scales 7

[1] See preceding paragraph.

PLATE III


alveolar ridges
11
13
14
12
gular
nuchal
marginals
intergular
gular
no inguinal shield present
16
17
5 vertebrals
15
supracaudals
2 claws
18
19
3 claws
20
EN.

2. Edges of jaws serrated (fig. 11), though only slightly so in young specimens 3

   Edges of jaws not serrated; forelimb with 5 claws 4

3. Forelimb with 4 claws only (fig. 12); enters sea at river mouths; range: Sumatra ..... four-toed terrapin (*Batagur baska*)

   Forelimb with 5 claws; range: Philippines; Borneo ..... saw-jawed terrapin (*Callagur borneoensis*)

4. One or 2 strong median ridges on palate region of upper jaw (fig. 13); range: Borneo; Sumatra ..... Bornean terrapin (*Orlitia borneoensis*)

PLATE III

FIG.

11. Head of four-toed terrapin (shell length 2 feet) showing serrated jaws.
12. Flat foot of four-toed terrapin showing claws.
13. Skull of four-toed terrapin (minus lower jaw) as viewed from below.
14. Skull of black terrapin (minus lower jaw) as viewed from below.
15. Saw-jawed terrapin (shell length 3 feet) with scaly skin on back of head.
16. Black-breasted hill-tortoise (shell length 5 inches), a species which withdraws its head in a straight line.
17. Long-necked water-tortoise (shell length 10 inches) showing sidewise method of withdrawing head; swimming specimen showing unusual position of intergular shield in this group.
18. Pitted-shelled turtle (shell length 20 inches) of New Guinea.
19. Shell of the rare pitted-shelled turtle from the Fly River.
20. Soft-shelled turtle ("shell" length 4 feet) showing three claws.

No median ridge on palate region of upper jaw (fig. 14) 5

5. Upper shell with 6 or 7 vertebral shields; range: Philippines; Borneo; Sumatra; Java ..... spotted-shelled terrapin (*Notochelys platynota*)

Upper shell with only 5 vertebral shields (fig. 15) 6

6. Eye the center of a yellow spot, another on temple; upper shell with a strong vertebral ridge but no lateral ones (except in young where side ones may be faintly indicated); range: Borneo; Sumatra; Java ..... black terrapin (*Siebenrockiella crassicollis*)

A yellow streak from nostril over eye to neck, another below the eye; upper shell with a strong vertebral ridge and 2 lateral ones (making 3 in all; fainter in old specimens); range: Java ..... three-ridged terrapin (*Malayemys subtrijuga*)

7. Both front and back portions of lower shell movable, completely closing shell; range: Philippines; Borneo; Sumatra; Java; Celebes; Moluccas; Ceram, etc. Malayan box-tortoise (*Cuora amboinensis*)

Front portion of lower shell not closing 8

8. Lower shell partly united to upper by ligament, its posterior part slightly movable in adult; range: Philippines; Borneo; Sumatra and adjacent islands serrate-shelled terrapin (*Cyclemys dentata*)

Lower shell united to upper by bony suture, immovable 9

9. Upper shell with 3 ridges; lower shell black edged with lighter; tail with soft spines at base; range: Philippines; Borneo; Sumatra; Batu Islands ..... black-breasted hill-tortoise (*Geoemyda s. spengleri*)

Upper shell with 1 or no ridges; lower shell not black; tail without spines at base 10

10. Upper shell with a vertebral ridge; lower shell moderately narrowed in front and without a notch, or only a slight one between the first and second pair of shields; all lower shields bearing radiating reddish brown lines on a yellow ground; range: Borneo; Sumatra, etc. ..... spiny hill-tortoise (*Geoemyda spinosa*)

Upper shell without trace of ridge; lower shell strongly narrowed in front and with a strong notch between first and second pair of shields; all lower shields uniform brown or yellow; range: Leyte Is., Philippines ..... Philippine hill-tortoise (*Geoemyda leytensis*)

B. Species occurring on and from Formosa northward.

11. Posterior part of lower shell rounded behind, slightly movable in adult, partly united by ligament with the upper shell; range: Formosa and Luchus yellow-edged terrapin (*Cyclemys f. flavomarginata*)

Posterior part of lower shell deeply notched behind, immovable, solidly united by bony suture with the upper shell 12

12. Upper jaw strongly hooked; no inguinal shield (fig. 16); range: Luchus south to Sumatra, etc. ..... black-breasted hill-tortoise (*Geoemyda s. spengleri*)

Upper jaw not hooked; an inguinal shield 13

13. Top of head in its posterior half covered with skin divided into small shields; range: southern Japan (introduced elsewhere by man) ..... Reeves' terrapin (*Geoclemys reevesi*)

Top of head entirely smooth 14

14. Head almost uniformly colored; lower shell mainly black; range: Japan only Japanese terrapin (*Clemmys japonica*)

Head with numerous narrow longitudinal stripes on sides; lower shell yellow with large brown blotch on each shield; range: Formosa; Hainan and mainland ..... Chinese terrapin (*Ocadia sinensis*)

Both the four-toed and saw-jawed terrapins have serrated edges to their beak-like jaws (fig. 11) and are herbivorous. Their olive-brown shells attain lengths of 2 and 3 feet respectively, that of the saw-jawed terrapin bearing three broad, black, lengthwise bands, their position indicated only by three series of spots in the young. Both species are good eating and, being timid, usually are captured in basket traps. Expert hunters go probing in sand banks to locate their nests. Each nest holds from ten to thirty hard-shelled eggs. These elongate eggs measure about the same for both species, roughly 3 by 1¾ inches. In size of egg and shell, and probably in other respects also, the Bornean terrapin does not differ greatly from the saw-jawed species.

While the foregoing probably haunt slow-flowing rivers, the other

kinds, all considerably smaller, apparently prefer shallow streams. The spotted-shelled terrapin's name is descriptive of the young only, for the adult's shell has radiating lines. On first being picked up, it hisses and discharges excrement, an unpleasant habit which it soon abandons when accustomed to being handled. The black or thick-necked terrapin, as it is sometimes called, is a voracious feeder on frogs, shellfish, worms, and even animal offal. Also carnivorous is the handsome three-ridged species with its yellow-streaked head. Its shell is only 8 inches in length, and the eggs measure about 1¾ by ¾ inches. The power to close its shell completely singles out the common Malayan box-tortoise and distinguishes it from all other members of the family inhabiting the Pacific. Shy and retiring, this vegetarian species is an inhabitant of marshes and rice fields in the lowlands.

The serrate-shelled terrapin, on the other hand, prefers upland streams and has been taken even above 400 feet. Its name derives from the serrations on the rear of its shell but this feature is common to several of its allies, particularly when young. Its yellowish brown, 9-inch shell is marked with darker brown, either as spots or in radiating lines. This active species enjoys a mixed diet, while the eggs it lays measure about 2¼ by 1¼ inches.

As their name implies, the three kinds of hill-tortoise also inhabit mountainous country where they ramble about the wild and wooded sections. That they spend much of their time on land may be deduced from an examination of their toes, which reveals the loss of the swimming web. It is when young that the spiny hill-tortoise presents the most striking appearance, for along either side of its upper shell it bears a series of spines; these gradually wear down and disappear with age. It is the commonest of the three, for the black-breasted species is rare and the Philippine form is scarcely known at all.

TORTOISES

True tortoises are absent from New Guinea and there are but two to be found in the Dutch East Indies. They are best distinguished by the following characters:

Upper shell with a nuchal and 2 supracaudal shields (see fig. 15 for named shields); range: Borneo; Sumatra; Asiatic mainland ..... Burmese brown tortoise (*Testudo emys*)

Upper shell without a nuchal and only a single supracaudal shield; range: Halmahera; Moluccas; Celebes ..... Forsten's tortoise (*Testudo forsteni*)

Both frequent hilly country, but while the little-known Forsten's tortoise is less than 7 inches in shell-length, the common Burmese species is three times as large and actually the biggest of all Asian true tortoises. Its size is scarcely an asset, for it is killed by the natives who prize the flesh.

This same edibility has spelled disaster for the famous giant tortoises inhabiting the Galápagos Islands. For centuries they remained unmolested by man or beast, growing to a ripe old age and developing numerous individual characteristics. When they were discovered it was assumed that the ocean had proved a barrier to interbreeding between the island groups and that the variations represented forms peculiar to each island. As a result, nearly a score of Galápagos tortoises received names, but it is doubtful if many represent really distinct forms, for recent observations upon the giant tortoises now established on the Seychelle Islands have revealed that the huge reptiles float from island to island by taking advantage of ocean currents. There are certainly two distinctive types on the Galápagos, the saddle-backed and the more ordinary shaped form; thin-shelled representatives of both occur on Charles Island.

When the islands were discovered by Spanish adventurers early in the sixteenth century, they were swarming with giant tortoises, hence the name Galápagos or "Tortoise Islands." On islands where no fresh water was obtainable, the tortoises subsisted on succulent cactus, but where water was available the reptiles drank deeply. Indeed it was through observation of the well-beaten paths made to and from water-holes that the Spaniards, on landing, were made aware of the presence of the tortoises. Though at times these tortoises are found

in the drier coastal lowlands, they prefer the moister uplands.

Belonging to a family that is essentially vegetarian, one captive Galápagos tortoise astonished its keeper by eating a rat which it had caught. At first sight the idea of a tortoise catching a rat appears ridiculous, but the reptile's technique called for no turn of speed. It just remained perfectly motionless until the rodent came within reach, then with a sudden lunge seized the rat in its jaws. Subsequently the tortoise caught a second rat and a pigeon. Then it was recalled that on the voyage from South America, the reptile had been accused of killing a macaw and an agouti which shared its cage. At the time the charges had been dismissed as preposterous. After the rat-catching incident, however, the huge tortoise was offered raw meat which it seized and greedily ate.

The shells of the largest Galápagos tortoises measured 4 feet in a straight line, and such old monsters weighed about 400 pounds. Fantastic speculations have been made regarding the age of such big fellows, but investigations by Major S. S. Flower reveal that there is no *authentic* record of a Galápagos tortoise having lived for more than 100 years. That they may live for 150 is highly probable, however, for a Mauritian giant tortoise is definitely known to have survived for 152 years.

With the development of the whaling industry, their chances for reaching old age became slender. In those pre-refrigeration days it did not take the whalers long to discover a welcome source of fresh meat in reptiles that could subsist for a long time without food. It became current routine for sailing ships to call at the islands to pick up a load of tortoises, and as many as 350 were removed from Charles Island in 1834 by a single vessel. In thirty-eight years over 13,000 were carried off by ships from a small area of New England, while many more were taken by whalers of other nationalities.

Obviously no slow-breeding animal could survive such a toll, so today tortoises are numerous only on Albemarle and are rare or extinct on other islands of the group. Subsidiary factors in the work of extermination were the dogs and pigs introduced by early voyagers. The animals, left to their own devices, dug up and devoured the tortoises'

eggs or killed any hatchlings they might find. For these facts I am chiefly indebted to the fascinating account written by the late Charles H. Townsend and published by the New York Zoological Society in 1925.

SNAPPING AND PITTED-SHELLED TURTLES

In the Fly River of New Guinea and nowhere else in the world are two species of turtles of which examples would be welcomed by any natural history museum. One is a snapper with a shell 13 inches in length. As this is the only snapping turtle living outside of the Americas, and as no American museum has an example of the New Guinean species, small wonder that it is much desired. Almost equally rare is the pitted-shelled turtle whose 20-inch shell is pitted and devoid of scales, statements to the contrary notwithstanding. The two-clawed flippers of this turtle distinguish it from all other non-marine species.

LONG-NECKED WATER-TORTOISES

New Guinea and Australia are also the home of a group of fresh-water tortoises known locally as long-necked tortoises, more rarely referred to as "snake-necked tortoises," a name usually reserved for their South American relatives. The second name is so descriptive that there is little need for further elaboration except to add that all the New Guinean species carry four claws on each foot. Of the ten kinds known from the New Guinea region, three have been separated under the name *Chelodina*, most readily recognized as follows:

Intergular shield of lower shell behind the gulars (fig. 17) .. *Chelodina*

Intergular shield of lower shell between the gulars ..... *Emydura*

It seems probable that they feed chiefly at night. Hans Gadow had some captive specimens which became so tame that they would leave the water at the sight of food and run with their ridiculously long necks outstretched to take the proffered tidbit, which they car-

ried back to the water before swallowing. Frogs, worms, or small insects form their natural fare but fish and raw beef prove equally acceptable.

Though no soft-shelled turtles occur in the New Guinea area, they are common to North America, Africa, and Asia, while five species from the last-named continent have invaded some of the Pacific islands. These turtles have been divided into three groups (genera), all of which occur on Borneo, Sumatra, and Java, in addition to the localities mentioned below. Unfortunately, these turtles have no well-known English names and the three species of *Trionyx* are separated by anatomical characters which cannot be discussed here.

KEY TO THE FIVE SOFT-SHELLED TURTLES IN THE DUTCH EAST INDIES

1.	Fleshy snout short; range includes Philippines	Cantor's soft-shelled turtle (*Pelochelys cantori*)
	Fleshy snout long	2
2.	Head very large; range includes Philippines	Malayan soft-shelled turtle (*Dogania subplana*)
	Head moderate or small; 3 species of which 1 (*T. sinensis*) occurs on Japan, Formosa, and Timor, another (*T. cartilagineus*) on Borneo and Sumatra; the third, recorded from Borneo, is based on a doubtful record	*Trionyx spp.*

In some parts of the United States these turtles have been appropriately dubbed "flapjacks" in allusion to their resemblance to a pancake. Less diagnostic is the term "mud turtles" from their habit of lying half-buried in mud in shallow water, ready to snap at any fish or frog which comes within reach of their razor-like jaws. Even on land they are surprisingly active and should be approached with caution; otherwise a long neck may be shot out with startling suddenness and a surprisingly vicious bite received.

4

Garial[1] and Crocodiles

Besides true crocodiles, the crocodile family includes garials, alligators, and caimans. The last two can be readily recognized, except in very young specimens, by the large fourth tooth of the lower jaw being invisible when the reptile's mouth is closed, since the tooth fits into a cavity provided for it. When a crocodile shuts its mouth the fourth tooth remains in full view, being accommodated only in a notch of the upper jaw. We need not concern ourselves with the alligators and caimans, for none occur nearer than China or South America.

Four of the crocodilians found on Pacific islands are also to be found upon the Asiatic mainland. One only, the sea-going or estuarine crocodile, is widespread among the islands; unfortunately it is also the worst man-eater of all crocodiles. But before proceeding to discuss their habits, it would be as well to know how to distinguish them.

Key to the Principal[2] Crocodilians of the Pacific Islands

1. Snout very long and slender; length of head at least 2½ times its greatest width; upper

[1] Usually spelled gharial in the East; frequently misspelled gavial in Europe owing to a clerical error in the latinization of the generic name of the common Indian species, *Gavialis gangeticus*.

[2] Two others have been described from the freshwaters of New Guinea and Mindoro, Philippine Islands. They are said to be distinguishable from each other only by skull characters. Both are closely related to the estuarine crocodile from which they are allegedly separable by the presence of (absent in the estuarine crocodile) enlarged shields on the neck just behind the head, also by the somewhat lower and more oblique ridges in front of the eyes. Series of crocodiles from these localities are much desired in order to determine whether these differences are constant.

jaw with 20 or 21 teeth on each side; range includes Borneo and Sumatra ..... Malayan garial (*Tomistoma schlegelii*)

Snout not slender; length of head not more than 2¼ times its greatest width; upper jaw with 17 to 19 teeth on each side 2

2. Five teeth on either side of end of snout before notch; snout not more than 1½ times as long as broad at base; no distinct ridges in front of eye; range includes Java ..... marsh crocodile (*Crocodylus palustris*)

Four teeth on either side of end of snout before notch; snout (except in very young) 1½ or more times as long as broad at base; a more or less strong ridge extending forward in front of each eye 3

3. Bony portions of shields on back in contact with each other across the body; 1 or 2 pairs of enlarged shields between the large ones on crown of head and those on nape; range includes Java ..... Siamese crocodile (*Crocodylus siamensis*)

Bony portions of shields on back separated from each other by soft skin; rarely any enlarged shields between the large ones on crown of head and those on nape; range includes Philippines; Borneo; Dutch East Indies; New Guinea; Solomons; Fijis, etc. ..... estuarine crocodile [1] (*Crocodylus porosus*)

[1] See footnote number 2 on page 40.

MALAYAN GARIAL

The extraordinary slender snout of the Malayan garial, though not quite so elongate as that of the common Indian species, is a remarkable

adaptation for coping with a fish diet. No fish, however slippery, would seem to have much chance of escape once it was caught between those four rows of needle-sharp teeth. The hard-shelled eggs of this garial measure about 4¼ by 2½ inches, or approximately the size of a goose's egg. Like those of all crocodilians, they appear ridiculously out of proportion to the reptile's bulk. Though it attains a length of 15 feet, the Malayan garial is allegedly timid and definitely not a menace to man. The natives of southern Borneo call it *buaia sapit*, while its Dyak name is *bediai sampit*. Above, its color is olive spotted with dark brown; sometimes the latter forms cross bands on the back. The tail always bears dark bars. Below, the garial is white.

MARSH CROCODILE

With a snout the very opposite of a garial's, the marsh crocodile, known also as swamp crocodile, broad-nosed crocodile, or mugger, somehow manages to catch plenty of fish. It is true that this diet is varied by eating the charred corpses carried down Indian rivers from the burning ghats, for the mugger is the common freshwater crocodile of India. There, when its depredations among the fish rouse the people's ire, certain races organize hunts to clear them out. Arming themselves only with poles, nets, and ropes, they probe the mud to drive the reptiles into the nets; once entangled, they are noosed and dragged ashore to be killed. It is said that when a mugger is lying beneath an overhanging bank it will permit itself to be noosed if the feat is performed slowly.

These facts reveal that some Indians at least have little respect for a mugger's prowess, reckoning it a timid creature. At the famous Mugger Pir, in the deserts outside Karachi, hundreds of muggers were kept under conditions that almost amounted to captivity. Originally a swamp, Mugger Pir now consists of a relatively small "tank" about which a high wall has been built. In 1913, when visited by Major S. S. Flower, there were only two dozen adult muggers to be seen. The reptiles were so obese that waddling ashore to bask called for quite an effort, and so tame that devotionally minded Hindus

could safely approach within a few feet to make their obeisance.

With these facts in mind, it is interesting to learn that the form of mugger occurring in certain parts of Ceylon turns man-eater and renders bathing a hazardous undertaking. In general, however, the mugger's diet is comprised of fish, frogs, terrapins, and an occasional bird or mammal. Deraniyagala tells us that the fish are captured by the simple expedient of waiting with gaping jaws till one swims within reach. A mugger bent on frogging swims slowly along the surface with mouth open to trap the hapless amphibians. When gulping down food, of whatever nature, the crocodile apparently raises its head above water.

During the dry season as marshes and ponds shrink under the burning rays of an equatorial sun, muggers migrate from pond to pond to feast upon the abundance of fish concentrated by the receding water. Such good living enables the crocodiles to lay up an accumulation of fat against the time when the drying pools force them to bury themselves in muddy burrows to await the onset of the rains. In this way they pass over the insufferably hot dry months. This "æstivation," as it is called, is similar in some respects to the more familiar "hibernation" undertaken by reptiles during the inhospitable wintry months of northern latitudes. In districts where muggers have been much pestered by man, they do not wait until the water is all gone, says Deraniyagala, but as soon as it has fallen below a level compatible with safety they migrate to the denser jungles, there to seek shelter beneath some rock until times are more propitious for poor crocodiles.

With the onset of the rainy season, the female mugger, using her forefeet, scratches a hole in a sandbank, preferably beneath the fringe of brushwood marking the limits reached by flood waters. There, when the hole has reached a depth of 18 inches, she deposits a score or more of eggs. These eggs range from 2⅜ to 2¾ inches in length, while their breadths may be 1½ to 1¾ inches. The wide variation is partly due to the size of the mugger that laid them.

During succeeding weeks the mother spends much of her time lying upon the nest, a habit calculated to protect the eggs from marauders and the excessive heat of midday. The incubation period is variously

reported as lasting from forty to sixty days. The young, when ready to emerge, croak so loudly that the noise can be heard 6 feet away. In response to the croaking, the mother mugger digs open the nest, thus facilitating the escape of the young. The length of each emergent hatchling is around 10 inches. Formerly the little reptile stood a chance of attaining a length of 15 feet, but since the introduction of firearms, the likelihood of its surpassing 12 feet is slim.

Young marsh crocodiles, being paler than their parents, show their black markings more distinctly, for adult muggers tend to become more or less uniform brownish olive above. Below they are white to yellowish, usually with traces of gray crossbars. As the occurrence of the marsh crocodile in the Dutch East Indies apparently depends on a single Javan record, the possibility that the report resulted from confusion with the following species, should not be overlooked.

SIAMESE CROCODILE

The Siamese crocodile does not differ from the marsh crocodile in color, and but little in size, for it is not known to exceed 12 feet. The eggs, however, are about 3 by 2 inches, according to Malcolm A. Smith, who spent many years in Siam and on whose account the following notes are based. At various times he kept a number of the 10-inch young, which proved to be entertaining captives. At that size they would croak when handled, or if anyone stamped nearby, or at an imitation of the croak—so that quite a conversation could be developed! But this curious high-pitched croak of their early youth was lost as they grew older.

Even at a tender age it was necessary to handle them respectfully, for they were only too ready to snap with their tooth-studded jaws. Though almost every kind of food was offered them, they refused to eat, so for the first two and a half months it was necessary to feed them forcibly on scraps of fish and raw meat. During this period they were kept in shallow water in a big earthenware bath containing bricks on which they could scramble, an arrangement that they fully appreciated. Subsequently they were released in a pond surrounded by a

30-in.-high barricade over which they could not climb. At one end the pond sloped gently, permitting the crocodiles to leave the water and bask upon the bank, while at night they sometimes went on excursions round the enclosure. Live fish introduced into their pond were apparently unmolested by the crocodiles, which were by then so tame that they would leave the water to take food from Dr. Smith's hand.

Under natural conditions the Siamese crocodile is a fish-eater and, though reported as sometimes seizing children, apparently does not attack adults. Alleging that so long as fish are plentiful the reptiles will not molest man, the natives bathe with impunity in waters inhabited by these crocodiles. In earlier days the people themselves preyed upon the reptiles. The hunters waited till a crocodile lay floating on the surface; then, bringing their boat alongside, one of their number would spring upon the reptile's back and fasten a cord about its jaws. The other end of the cord was securely attached to their boat. Bishop Pallegaix, from whose ninety-year-old book Malcolm Smith quotes, states that he saw about fifty crocodiles of various sizes tethered to the poles which supported the houses in an Annamite village outside Bangkok. The flesh was marketed like pork but commanded a much lower price. It is still eaten by the people, though no longer as a regular article of diet.

ESTUARINE CROCODILE

Whereas both marsh and Siamese crocodiles normally frequent the upper reaches of rivers and are decidedly rare in the Dutch East Indies, the estuarine crocodile haunts brackish water and swamplands about river mouths below tidal limits.[1] The ocean itself is no barrier to this man-eating monster, which more than once has been taken at sea. This is attested also by its extensive distribution, which includes not only parts of the Asiatic mainland and northern Australia, but all the major tropical islands with which we are concerned here.

In coloration much like the other two species, the estuarine surpasses both in length. The largest record is based on a skull from

[1] See footnote number 2 on page 40.

Bengal in the British Museum, taken from an animal said by the donor to be 33 feet in length and to measure 13 feet 8 inches around the middle. Second only is a 3-foot skull in Harvard's Museum of Comparative Zoölogy, from a 29-foot crocodile killed at Jala Jala, near Lake Bombon in the Philippines.[1] According to one of its slayers, George R. Russell, a Boston merchant who lived for a time in the Philippines, the reptile measured 11 feet around the body and had killed a great many people before meeting its own end. This happened nearly 120 years ago, and today it is most unusual for an estuarine crocodile to exceed a length of more than 20 feet.

Obviously a creature of such dimensions finds it easy to overpower even large animals, and once it has found how defenceless is the average man or woman when taken unawares, the estuarine crocodile becomes as confirmed a man-eater as the most persistent man-killing tiger. Owing to the toll they take of village life, these man-eaters are greatly feared and hated. In regions where they form a constant menace, some of the natives specialize in their destruction. How this may be achieved is illustrated by the following account of the killing of one that had carried off a boy.

Upon arrival at the place where the victim had been taken, the hunter and his assistant moored their canoe. Quietly the men lay concealed in the boat until they observed the crocodile come up to float. This was the signal for the hunter's son to enter the water and splash about until the crocodile took notice. No sooner had the reptile submerged, the better to approach its prospective quarry unseen, than the lad scrambled back into the canoe. Presently, as had been anticipated, the crocodile rose alongside and was greeted with harpoons, one being securely planted in its hide. Then ensued a chase in which many of the villagers took part; a second harpoon pierced the reptile's head and presently the beast was dragged ashore. When its stomach was opened up, various gold and silver ornaments were revealed—mute evidence to the identity and fate of previous victims.

It is natural that women, who daily wade into the shallows to

[1] These 29- and 33-foot measurements are questioned by K. P. Schmidt of the Chicago Natural History Museum.

wash clothes or fill their water pots, should be taken more often than men. Even young crocodiles may make the attempt, and Deraniyagala tells of one that seized a woman by the hand. After a tussle she managed to escape by forcing open the reptile's jaws with her free hand. A 9-foot estuarine crocodile caused two deaths before it was brought to book, while, according to J. W. Bennett, a human corpse complete but for the head was found in the stomach of a 17½-foot crocodile.

The old adage "eternal vigilance is the price of safety" was never more true than for those living near the haunts of the estuarine crocodile. One does not have to enter the water to provide a meal for these great reptiles as they lie concealed in the muddy waters of lagoon or river. Often the first intimation of their presence received by some unwary stroller at the water's edge is when, his legs swept suddenly from beneath him by a deftly wielded tail, he is seized in the vise-like grip of great jaws to disappear in swirling water whose surface quickly resumes its normal placid appearance regardless of the human tragedy it conceals.

So far as people are concerned, my colleague Dr. Darlington, curator of beetles in this museum, is better qualified to speak. Captain P. J. Darlington, Jr., was serving with an anti-malarial unit in New Britain when the incident occurred. He had worked his way out along a submerged log to the middle of a swamp and was dipping a test-tube in the clear water when he saw the crocodile rise. He started to return but, slipping on the log, plunged into the water. As he came to the surface the 10-foot reptile seized him by the arms and employed the customary technique of rolling over and over as it backed away. Darlington, though about 6 feet tall and weighing 170 pounds, was tossed over and over as he was carried to the bottom.

Darlington struggled and kicked—and it was like trying to kick in a sea of molasses. His legs seemed heavy as lead and it was hard to force his muscles to respond. Seconds seemed like hours before the crocodile gaped and released him, possibly on account of Darlington's landing a blow on its soft underside. Gasping, the captain struggled to the surface and swam to the edge of the pool. Hastily he tried to clamber up the bank, but slipped in the mud and rolled back into the

ooze. On a second attempt he was more successful. Then for the first time he realized the painfulness of his wounds. The left hand had been punctured by several of the crocodile's teeth, while in addition to dislocation and compound fracture of the ulna the muscles and ligaments of the right arm were torn. Despite the severity of these injuries, within three or four days Darlington was able to shave and write with his left hand. He subsequently made a good recovery.

After seizing its victim, the estuarine crocodile may remain hidden near its lair; but when the prey has to be carried a distance, the nostril-bearing tip of the crocodile's snout will appear from time to time, showing that it must come up for air when swimming, particularly if there has been a prolonged struggle. Once at the lair, the reptile satisfies immediate hunger with the softer parts, and is then believed to wedge the victim's body among a tangle of roots so that decomposition may facilitate dismemberment.

Larger animals are most frequently taken in the act of drinking. Seizing such a beast by the snout, the crocodile twists over and over with great rapidity as simultaneously it backs into deeper water. These actions, combined with the suddenness of the attack, usually result in felling the prey. Its efficaciousness is attested by the reported killing of an adult Suffolk-Punch horse in Australia. Though dray horses of this breed turn the scale at 2,000 pounds and can give a pull of 2 tons, it availed nothing against the reptile. Occasionally a calf, or more rarely an adult, water buffalo may be attacked, but generally speaking this animal enjoys a relative immunity. This may be attributed to the fight which a water buffalo, itself semi-aquatic, can put up, and partly to its gregarious habits. Consequently a herd of buffalo may be seen wallowing in close proximity to floating crocodiles.

It should not be supposed that the estuarine crocodile is wholly dependent upon brute force to secure its food; it displays cunning and is capable of surprising speed and accurate timing. Deraniyagala records the fate of an active adult langur monkey which, escaping from its cage, dashed into an enclosure where a 14-foot crocodile was lying in a 3-foot-deep cement trough. The seemingly somnolent reptile, suddenly hurling itself upward so that its forward half was clear

of the water, seized the langur as it sprang. A crunch and a gulp, and the monkey disappeared forever. Apparently five years of captivity had not affected the crocodile's activity. Yet this particular individual, when first caught, could be fed only by playing a hose lightly on its face. This caused it to gape widely and provide the keeper with an opportunity to thrust food down its throat.

While the natural food of young crocodiles consists of water beetles, prawns, crabs, fish, frogs, and terrapins, in captivity they will take scraps of meat. Hans Gadow received from Ceylon two dozen estuarine crocodiles still only a foot in length. Even at that age they differed temperamentally from the young marsh crocodiles kept by Smith, for from the first they fed voraciously on strips of fish, and subsequently on sheep's heart and lungs. The shyest were the most vicious. Despite frequent handling they became no tamer, only bolder and more confident, snapping at the hand that fed them instead of huddling together or diving to the bottom of their tank to hide, as on first arrival. At night especially, they liked to float with just their nostrils above water. Though a temperature of 60 degrees F. did them no harm, it was noticed that they would not feed until it rose above 75 degrees, while 85 degrees was what they liked best. If raised to 95 degrees, the reptiles left the water, yet had to be prevented from lying on the hot water pipes!

During the first year they grew to 18 or 20 inches. In three years some were actually 4 feet long, though this was above the average. The rate of growth slows up with advancing years for in Frankfort Zoo a 15½-foot crocodile took two years to add another 10 inches. In captivity their quarrelsomeness is apt to lead to an untimely death. Such was the case with the two longest-lived examples in the London Zoo, where they had resided for nearly sixteen and eleven years respectively. As it is known that the Nile crocodile lives for over twenty-five years, there seems no reason why the estuarine species should not do so also.

Competition for food is by no means the only cause of the desperate fights between estuarine crocodiles. Undoubtedly many of the festering wounds which scar old males, and probably make the sufferer more

ferocious, result from the contests for females which take place in the breeding season. During this season the males are said to grunt throughout the night, and at its conclusion the females retire to some remote grove where there is an abundance of leaf mold. The spot selected is usually about 200 feet from the water's edge, and if unmolested the crocodile will return to the same site year after year. Instead of *digging* a hole like the other crocodiles discussed here, the estuarine *builds* a dome-shaped nest of flag leaves in which to lay its twenty-five to sixty eggs. Each of these measures about 3 by 2 inches.

Within a yard or so of the nest the mother digs two wallows wider than, but not so long as, her body. The wallows soon fill with mud and water, and in one or the other the crocodile remains during the period of incubation. As moisture is undoubtedly necessary for the eggs, it is believed by many natives that the mother wets the nest by periodic thrashing of her tail. However, Deraniyagala, to whose careful observations I am indebted for many of these facts, found no support for the story in the way of muddy spray upon the nests which he examined.

From the discolored and alga-encrusted state of the teeth of two emaciated guarding females shot by Deraniyagala, he concludes that they eat but little during the entire period of their self-appointed vigil. Unguarded, their eggs would run the risk of discovery by many foes such as jackals, otters, mongooses, and monitor lizards. As the hatching of the eggs corresponds more or less with the advent of the rainy season, the resulting flooding of the surrounding area is calculated to reduce the risks run by the young from the many creatures which would like to prey upon them.

So far as the adults are concerned, it may be supposed that they have few enemies other than man, who hunts or traps the estuarine crocodile in a variety of ways. The Karens of the Irrawaddy delta like the flesh of this species, which they say tastes like shark and chicken. So, taking advantage of the reptile's habit of coming ashore in the moonlight, Karen hunters harpoon them as they lie upon the sandbanks. The detachable harpoon head is fastened to a light line

securely tied to a stout bamboo growing on the river-bank. The wounded crocodile rushes into the water there to expend its great strength unavailingly against the flexible bamboo. When finally exhausted, the reptile is hauled ashore by the hunters and dispatched.

Sinhalese fishermen employ a line and hook, the latter secured by a multiplicity of fine cords which slip between the crocodile's teeth where they cannot be severed. This multiple-cord idea is used also by the Burmans when they affix hooks to a small raft upon which they place the bait—usually a duck. In Ceylon sometimes a stout palisade is employed. Above its only entrance is a drop door which falls behind the crocodile when it treads upon some releasing mechanism or pulls at the bait.

More quickly effective is the European method which calls for an elongate but divided stockade. In its inner compartment the live bait is safe from harm while the entrance to the outer is guarded by a down-pointing rifle. The strings connecting with the trigger should be carefully adjusted to permit the crocodile's long snout to pass beneath the muzzle before the cartridge is fired. Then a bullet through the brain will abruptly end the career of a potential man-eater.

5

Lizards

Most people have a fairly clear idea in their own minds as to what a lizard looks like, and would perhaps describe it as "any scaly four-legged reptile that is not a crocodile or turtle." While this definition is certainly applicable to the vast majority of lizards, it fails to include several families of burrowing forms whose members, through loss of limbs, are definitely worm- or snake-like. For this and other reasons based on their close affinities to snakes, both groups are included in the same order of scaly reptiles (SQUAMATA), of which lizards form only a suborder (SAURIA or LACERTILIA) as already indicated on p. 8.

There also were cited certain distinguishing characters, to which may now be added other more or less helpful features. For example, no snake has an external ear-opening, while most, though not all, lizards show such an aperture. While every snake can withdraw its entire tongue within a sheath lying on the floor of the mouth, no limbless lizard can do so completely. In some species a sheath is present at the base of the tongue, while in monitor lizards, which are four-footed, it is about as well developed as in snakes.

As a group, lizards have prospered exceedingly and number well over 2,000 different kinds; of these about 400 may be found in the Pacific. Lizards have successfully invaded every continent and in Scandinavia even reach to the arctic circle 70 degrees N. As one approaches the colder latitudes there are fewer species, while in tropical and subtropical regions lizards excel both in numbers and in variety of form, size, and color. As might be expected, they exhibit a bewildering diversity of habits; some spend much of their time in water,

either fresh or salt, while others again have become adapted to a life in arid or waterless deserts.

A flattened or depressed body often characterizes these desert-dwelling lizards and facilitates their hiding beneath stones or creeping into rock fissures. Many rock-haunting species are provided with specialized toes which enable them to run swiftly up a smooth surface. With the advent of man, they have shifted their quarters to the walls of his houses where a greater abundance of insect life assures them of an easier livelihood. Tree-dwellers tend to have compressed bodies which render them less conspicuous as they bask upon a branch. Ground-living forms show wide diversity, some being gross and sluggish, while others with long whiplash tails are clearly designed for speed. Such subterranean burrowers as have limbs often hold them close to their sides and progress by strenuous wriggling in much the same fashion as snakes. Strangely enough, the few aquatic forms swim well without webbed feet. In fact, the only lizard with strongly webbed feet is found in the arid deserts of South West Africa, where webbing assists it in running over the shifting sands!

Other interesting adaptations can best be discussed under one or another of the ten different families to which the lizards of the Pacific islands are assigned. It is hoped that the following key may prove of some assistance in recognizing to which family in this region any lizard belongs.

Key to the Lizard Families of the Pacific[1]

1. Forelimbs present (except in the Philippine worm-skink which has distinct eyes) 2

   Forelimbs absent; body elongate, worm-like or snake-like 9

[1] To which the descriptions and ranges apply and not necessarily to non-Pacific members of certain families. Unfortunately, external similarities make it impossible to devise a key based entirely on external characters or outward appearance; nor has it been possible to follow the correct systematic arrangement of the families as given in the chart on p. 244.

PLATE IV

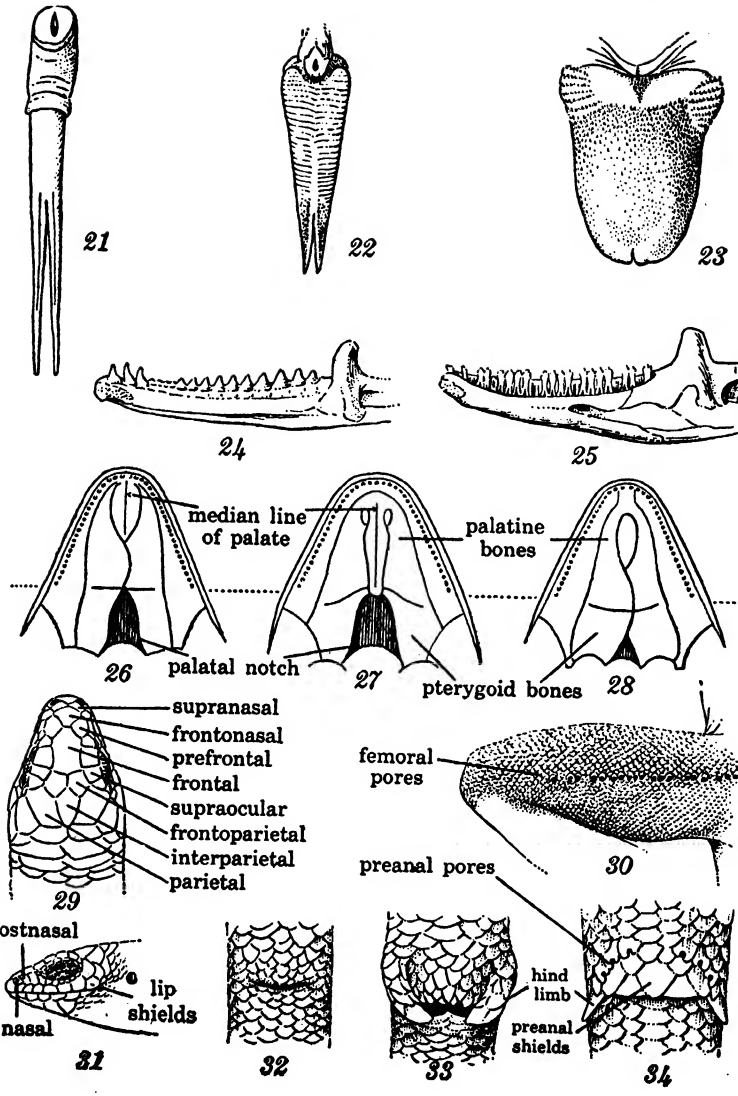

21
22
23
24
25
median line of palate
palatine bones
26
palatal notch
27
pterygoid bones
28
supranasal
frontonasal
prefrontal
frontal
supraocular
frontoparietal
interparietal
parietal
29
femoral pores
preanal pores
30
postnasal
lip shields
nasal
31
32
hind limb
preanal shields
33
34

PLATE IV

FIG.

21. Smooth, long, slender tongue of a water-monitor, forked for at least half its length.
22. Ridged tongue of a six-lined lizard is forked for only about a third of its length.
23. Thick, fleshy tongue of a gecko is nearly covered by little papillæ and is entire or slightly notched at the tip.
24. Inner aspect of lower jaw of an agamid lizard showing teeth attached to the summit.
25. Inner aspect of lower jaw of an iguanid lizard showing teeth attached along inner surface of parapet.
26. Skull of a skink (*Mabuya*) from below to show palatine bones in contact in the middle of the palate.
27. Skull of a skink (*Egernia*) from below to show palatine bones separated in the middle of the palate.
28. Skull of a skink (*Dasia*) from below to show pterygoid bones in contact with the palatal notch not extending forward as far as an imaginary dotted line connecting the eyes.
29. Head of a skink (*Eumeces*) viewed from above, with shields named.
30. Thigh of a male Lesueur's lizard viewed from below to show femoral pores.
31. Head of a skink (*Lygosoma*) viewed from side to show nostril pierced in an entire nasal shield, and lower eyelid with a transparent disk.
32. Anal opening of limbless female worm-skink from New Guinea.
33. Anal opening of male worm-skink showing vestigial hind limbs.
34. Anal opening of Jicar's scale-foot lizard of New Guinea, showing preanal pores and scale-like vestigial hind limbs.

2. Tongue smooth, very long and slender, deeply divided or forked for half its length (fig. 21), capable of withdrawal into a sheath at its base, in life constantly flickering in and out like that of a snake; head covered with small scales, body with gran-

ules; range: most islands from the Philippines to the Solomons, also some others .. monitors (VARANIDÆ)

Tongue smooth or covered with papillæ, neither very long nor slender, often broad, neither deeply divided nor completely withdrawable into a sheath at its base if a sheath is present, in life rarely protruded except when drinking; head covered with granules, small scales, or large shields 3

3. Tongue divided for about one third of its length (fig. 22) 4

Tongue entire or slightly notched (fig. 23) 5

4. Ears concealed; lips without shields; back and tail with longitudinal rows of wart-like tubercles each bearing a small keeled scale and giving it a distinctly crocodile appearance; belly scales small and smooth; tail only slightly longer than head and body; range: Borneo (only one species is known) earless lizard (LANTHANOTIDÆ)

Eardrum distinct; lips covered with shields; back and tail covered with flattish and but slightly keeled scales; belly scales large and keeled; tail (when not reproduced) like a whiplash, being 3 or 4 times as long as head and body combined; range: Sakhalin Island southwest to Sumatra and Java (only 4 species on Pacific islands; many elsewhere) .. true lizards (LACERTIDÆ

5. Upper surface of head covered by granules or small irregular scales; tongue rather broad and short, not or but slightly notched at the tip 6

Upper surface of head covered by symmetrical shields 8

6. Eyelids immovable (in Pacific species except the cat geckos); body depressed; range: most Pacific islands ..... geckos (GEKKONIDÆ)

Eyelids movable, covering the eye; body (in Pacific species) more or less compressed or robust 7

7. Teeth attached to the summits of the jaws (fig. 24); range: Luchus southwest to Sumatra east to Solomons, etc. ..... agamids (AGAMIDÆ)

Teeth attached to the inner side of the external parapet of the jaws (fig. 25); range: Fijis; Tongas; Galápagos ..... iguanids (IGUANIDÆ)

8. Pupil round; eyelids movable or immovable; limbs present or absent; range: most Pacific islands ..... skinks (SCINCIDÆ)

9. Eye hidden beneath scales; end of snout covered with 3 large shields; snout short and blunt; hind limbs in males represented by scarcely noticeable flaps on either side of anus (fig. 33), females limbless (fig. 32); tail short and blunt; range: Philippines southwest to Sumatra east to New Guinea blind-skinks (DIBAMIDÆ)

Eye distinct; end of snout covered with numerous small shields; tail long and tapering 10

10. Snout long and pointed; scales smooth; hind limbs represented by scarcely noticeable flaps

on either side of anus (fig. 34); range: New Guinea; Aru, Yule, and Valise Islands .... scale-foots (PYGOPODIDÆ)

Snout moderately blunt; scales strongly keeled; limbless; range: Formosa; Borneo . "glass-snakes" (ANGUIDÆ)

MONITORS

The only lizards ever mistaken for crocodiles are the monitors. The error arises chiefly on account of their size, for many monitors are veritable giants of the lizard suborder, though a few species are small. Several explanations are current as to the reason for these reptiles being called "monitors" or "warning lizards." The most plausible is that it arose through a misunderstanding due to the similarity of "warning" to "*ouran*," the Arabic name for a lizard. Another version credits the monitors with warning crocodiles of the approach of man. This is by no means so unlikely as may at first appear, for several kinds of monitors are as much at home in water as they are on land. Such species, when disturbed on land, make such a commotion as they dash through the undergrowth and plunge into the river that the noise may well arouse the more somnolent crocodiles.

This is not to suggest that the monitor is actuated by any spirit of generosity or gratitude, even though the crocodile does provide it with eggs to eat. To judge by the way the maternal crocodile chases a monitor from the vicinity of her nest, one may assume that little love is lost between them. While the plundering of crocodile nests by monitors commends them as objects worthy of protection, in many places it is offset by their robbing of hen roosts. Nor is it merely the eggs they come in search of, but the chickens, for with monitors variety is the spice of diet.

While beetles, caterpillars, grasshoppers, millipedes, slugs, snails, and crabs are the principal items of fare for young monitors, as they increase in size and strength their diet seems limited only by what they cannot overpower, for frogs, lizards, the smaller snakes, and mammals follow. Neither do the terms "insectivorous" and "carnivorous" ade-

quately describe the monitors, for they are confirmed carrion feeders and even eat human corpses when opportunity offers. In the Philippines the appreciation of man and monitor is mutual, for Taylor tells us that monitors are eaten by many of the islanders. These know them by various names such as *bañas* (Ilocano), *bayawak* (Tagalog), *guibang* (Manobo), and *halo* (Visayan).

To many Australians they are "*goanna*," an unfortunate misnomer resulting from confusion with "iguana" of which goanna is a corruption. Actually there are no iguanids in either Australia or Asia, and monitors and iguanas have little but their large size in common. Monitors not only lack the crest on crown and back which is characteristic of the larger iguanas, but their bodies are more or less depressed, instead of being compressed as is the case with the tree-dwelling iguanas though this is less noticeable in the land and marine iguanas of the Galápagos.

While non-poisonous, a cornered monitor is no mean opponent, for it possesses a formidable weapon in its long tough tail. In the water-loving or aquatic species this tail is strongly compressed and has a hard, sharp keel along its upper side. Depressing its head, the monitor employs this tail as a whip, and lashing out with startling suddenness, may inflict severe blows on the shins of unwary bystanders. As it strikes, the tail is turned so that the blow is delivered by the hard keel and, in the case of a large monitor, with sufficient force to break a dog's leg. The efficacy of this weapon is attested to by zoo-keepers throughout the world, who evince a marked reluctance to enter a cage occupied by the larger monitors. These, with the exception of the Komodo monitor, appear to be more or less savage in confinement. Confinement has to be solitary, or limited to other lizards of comparable size, for a monitor may kill and eat smaller companions.

Despite the intractability displayed in captivity, monitors which escaped after prolonged confinement, have been known to return in due course to their old cages and make frantic efforts to gain admission. In one such instance the lizard was noticeably emaciated after an absence of ten days; evidently it had decided that regular rations were preferable to freedom and daily want.

Nearly a score of different kinds of monitors are to be found on the islands of the Pacific, but only the most important can be discussed. Of these, pride of place must be accorded to the Komodo monitor (see wrapper), which in the matter of weight and bulk surpasses every other living lizard known. Yet despite its size, this colossal species was only discovered in 1912.

KOMODO MONITOR

Apparently Komodo monitors are confined to a group of islands in the Lesser Sundas, being known only from Komodo, Ringa, and a small area on the west coast of Flores; probably they occur also on Padar.[9] Even on these islands their distribution is largely restricted to rough country where *alang-alang* grass and bushes spring up between the bare rocks, with here and there a solitary *lontar* palm growing among the scattered trees. In the dry season such country presents a barren aspect, but in spite of this, deer and wild pigs are often plentiful.

Boeaja or *buaja darat* (= land crocodile), the name bestowed on this monitor by the local natives, is particularly apt for so ponderous a reptile. Though extremely bulky, in length it probably does not exceed 10 feet and tales of 23-foot dragon lizards may be discounted until specimens of such dimensions are produced in proof.

The big fellows are dull brown or almost blackish, but younger ones, even 7-footers, are brighter. These give a general impression of a chestnut shade, but closer scrutiny reveals the skin itself as lime-green on the neck and chest and almost carroty orange on the shoulders and back. Embedded in the skin are the almost entirely brown granules, and it is this combination which produces a chestnut appearance. When the long forked tongue flickers out, its pale yellow color is seen to match that of the eyelids and stand out in sharp contrast to the red lining of the mouth.

Aided by their recurved teeth, long claws, and strong limbs, these powerful lizards are said to prey on deer, pigs, and other animals. Apparently in their island homes they have assumed the role usually played by leopards, tigers, or man, and it is fair to assume that it is

owing to the absence of large mammalian carnivores that, like the tortoises of the Galápagos Islands, these lizards have attained their large size.

By using deer or pigs as bait, men have successfully box-trapped many of these monitors and subsequently shipped them to various zoos. They have often arrived there in poor condition with cankered jaws, septic feet, or afflicted by abscesses. Careful treatment, however, supplemented by artificial sunlight and a tropical temperature, has been successful in restoring them to health. Proof of this is furnished by three different zoological gardens which have kept Komodo monitors for nine years or more.

In captivity these giant lizards become quite docile. One even permitted children to pester it without retaliation, followed its keeper about like a dog and, if hungry, came when called to take food from the hand. So much was demonstrated in London Zoo by two 7-foot monitors, one of which even permitted the curator, Miss Joan Procter, to hold its tail and use it as a steering rudder on their walks about the premises. Only when actually bolting food—and they could swallow a large fowl in a couple of gulps—were they untrustworthy. Their diet of fowls was varied by eggs which Sumbawa, as the female monitor was called, would pick up carefully one at a time or neatly accept from a stout metal tablespoon. On one occasion the heavy handle was bitten through and the bowl of the spoon taken with the egg! In spite of this exhibition of docility, it should not be assumed that a wild or freshly caught monitor is anything but a dangerous creature.

COMMON WATER-MONITOR

While the tail of a Komodo monitor is only about half the reptile's total length, that of the common water-monitor is about once and a half as long as its head and body. This accounts for the smaller bulk of the water-monitor, which attains a maximum length of 8 feet. Besides the Asiatic mainland this lizard ranges from the Philippines and Sumatra east to Celebes. Undoubtedly this extensive distribution

is largely due to its prowess as a swimmer, for water-monitors, like the estuarine crocodile, have been seen swimming far out to sea. Another characteristic which the lizard shares with its larger relative is a partiality for coastal canals and river deltas.

Such is the fondness for water displayed by these monitors that they seek refuge in it when molested and remain below the surface for a considerable time. This is made possible by a valvular arrangement in the nostril. As may be surmised from an examination of the large and exposed eardrum, a monitor's hearing is exceptionally acute. If disturbed when basking on a tree overhanging a stream, the lizard unhesitatingly plunges in and swims away with strokes of its powerful tail till it reaches the half-submerged entrance to its hole in the bank. In the hole, or in a hollow tree growing at the water's edge, the monitor lays her eggs. These range from fifteen to thirty in number, and are about 1¾ by 2¾ inches in size; the shell is soft and parchment-like. The flavor of a monitor's egg is alleged to be much the same as that of a turtle's.

On hatching, a young water-monitor is a beautiful little reptile. Its back and tail exhibit transverse rows of yellow spots on a black ground, the snout is lighter with black bands crossing the lips and chin, and a yellow-bordered black streak extends back from the eye. Below it is white or yellow. With age the contrasting colors tone down to some extent, but a series of dark vertical streaks on the sides have earned for it the name of banded monitor. Such markings, however, are common to several other species.

By some tribes the gaudy young are mistakenly regarded as venomous, and in India are called *bis-cobra.* In Ceylon the adult is known as *kabara-goya,* in Malaya as *biawak.* Those natives who appreciate the flesh of monitors, train dogs to hunt them down, then dig them from their burrows or capture them by means of a noose on the end of a bamboo. When brought to bay, the monitor opens its mouth, distends its throat and hisses loudly while awaiting an opportunity to lash out with its tail.

That such a reptile could be tamed might seem improbable had it not been proved possible. Raymond L. Ditmars tells us that four of

these monitors kept in the reptile house at the Bronx Zoo became so remarkably docile that the largest would actually leave its cage to climb up its keeper. In summer it was decided to move them to an outdoor enclosure, where sunlight and fresh air wrought a startling change in temperament.

The first time that food was taken to them in their new quarters by their keeper, Charles Snyder, he was greeted by a loud hiss from his former favorite. The big lizard inflated menacingly and assumed an offensive posture as if about to use its tail. Snyder side-stepped but the monitor was too quick for him; its tail struck the dish of eggs he was carrying and scattered its contents far and wide. As Snyder retreated, he noted with surprise that all four monitors were hissing in a most unfriendly way. Later, when the keeper again entered the enclosure to see if the food had been eaten, his old favorite rushed at him open-mouthed, then swinging sidewise, dealt him a blow on the arm that raised a severe welt. All summer long these monitors remained savage and intractable. When fall came, they were returned to their former quarters and within a fortnight they had assumed their previous docility.

Ditmars remarks that the largest of these monitors would make a meal of as many as ten hens' eggs, swallowing them one after another so quickly that the unbroken shells might be heard striking together as they passed down the reptile's gullet. On reaching the stomach they were crushed by muscular action, and in the course of a day or two the powerful gastric secretions completely dissolved the shells, following which the lime is disposed of in the usual way.

This big monitor was usually fed on freshly killed pigeons but could, though with some difficulty, bolt a three-quarters-grown rabbit. Smaller animals are killed by monitors in much the same manner as a terrier treats a rat. Rushing upon its prey, the lizard seizes and shakes it violently. As soon as it is dead, the creature, if small, is shifted about in the monitor's jaws till its head is directed toward the reptile's throat, down which it disappears in a few jerky gulps. With larger prey the procedure is slightly different. As soon as all signs of life are gone, it is dropped. Then follows an investigation by the

flickering tongue (fig. 21), after which the monitor, using its broad muzzle, pushes the body about for a time before taking it up by the head and gulping it down.

In Amsterdam Zoological Gardens a water-monitor lived for eleven years, while various other records of over ten years testify to this lizard's ability to adjust itself to confinement.

OTHER WATER-MONITORS

From Celebes to the Solomons and northwards to the Carolines and Marshalls, the water-monitor is represented by an equally abundant and somewhat similarly colored species,[1] though the underside of young examples may display a network of black lines. It differs from the other three monitors mentioned in having smooth belly scales, but a lens is sometimes necessary before the keel or fine rib can be distinguished on the belly scales of some of the others. While the nostril in these others is oval or oblique, that of the Indies monitor is allegedly round; actually it is best described as roundish to oval.

In the Borneo-Sumatra-Java area occurs another species which shows little fear of the sea. Duméril's monitor, as it is called, haunts mangroves or dense evergreen forests where these grow close to the coast. If disturbed by dogs, instead of taking to the trees, these 4-foot-long lizards have been seen to dash across the beach and seek safety in the ocean.

All four of the monitors I have mentioned have compressed tails, though that of the Komodo dragon is but slightly so in conformity with its more terrestrial habits. The following key may serve to separate them, but it should be remembered that more than a dozen other kinds of monitors occur on one or another of the Pacific islands.

Key to Four of the Commonest Pacific Monitors

1. Nostril at least twice (twice in young, thrice in adults) as far from the eye as from the end of the snout 2

[1] *Varanus indicus.*

Nostril nearer to, or only slightly farther from, the eye than the end of the snout; middle row of scales (supraoculars) above eye enlarged transversely 3

2. Middle row of scales (supraoculars) above eye not differing from the adjacent ones; tail only slightly longer than head and body — Komodo land-monitor (*Varanus komodoensis*)

Middle row of scales (supraoculars) above eye enlarged transversely; tail about 1½ times as long as the head and body ..... — common water-monitor (*V. salvator*)

3. Nostril roundish to oval, only slightly farther from the eye than from the end of the snout; scales on belly smooth ..... — Indies water-monitor (*V. indicus*)

Nostril an oblique slit, only half as far from the eye as it is from the end of the snout; scales on belly slightly keeled ..... — Duméril's water-monitor (*V. dumerilii*)

EARLESS LIZARD

In Borneo is to be found a 16-inch lizard that looks more like a diminutive crocodile than any monitor, an effect due to the back and tail being protected by ridges of raised tubercles. This reddish brown reptile, known only from along the Rejang River in the Sadong District of Sarawak, is coveted by every museum, for few possess an example. No living specimen has ever reached America or Europe. Its chief interest centers about an alleged relationship to the Gila monster and beaded lizards of Arizona and Mexico, the only known poisonous lizards in the world. The teeth of the Bornean earless lizard, however, show no trace of grooves, so it cannot be stated too emphatically that, notwithstanding native statements and superstitions to the contrary, no lizard throughout the Pacific is poisonous.

SIX-LINED LIZARD

Also in Borneo, but this time in Sumatra and Java as well, a representative of the typical lizards occurs. Obviously the six-lined lizard, as it is called, arrived on the islands from the Asiatic mainland where it, or its forms, enjoy an extensive distribution from the eastern Himalayas to China and on the islands from Japan to Formosa. Of the many other members of this family scattered over Asia, Africa, and Europe, undoubtedly the best known are the wall and green lizards of the Mediterranean region.

To the ordinary observer the most outstanding characteristic of the six-lined lizard is its amazingly long and slender tail—a tail often three or four times longer than the combined length of head and body. The tail is often short, however, for, in common with all members of the family and many other lizards as well, this reptile parts with its tail. Seizing the tail usually causes this to happen, though it is not essential, for in most lizards automatic fracture is achieved by muscular impulse imparted to a cartilaginous band across the middle of each caudal vertebra. Other muscles serve as sphincters to close the severed artery and thus prevent bleeding.

From the stump a new tail soon begins to sprout, but instead of reproducing a series of bony vertebræ a simple cartilaginous rod develops to support the new growth, which rarely attains the length of the original. Occasionally two tails may arise from the stump, but usually the second appears as an offshoot from an incomplete fracture. While the scaling of the regenerated portion may resemble that on the original, quite frequently it differs considerably and in such cases reverts to scaling of a less specialized and probably ancestral type.

The lizard's involuntary purpose in parting with so useful a balancing organ is fairly obvious: a pursuing snake or other foe is most likely to overtake and seize the tail of a fleeing lizard. By discarding it, the lizard increases its chances of escape while the enemy is preoccupied with swallowing the severed section. In its role of decoy, the discarded portion performs effectively by coiling and uncoiling, rolling over and over, and even jumping about by reflexes that persist

for some minutes after the tail is broken off. By parting with its tail in instalments, one of my lizards escaped from our cat twice in the course of a week.

Six-lined lizards inhabit long-grass country, on Java up to altitudes of 4,000 feet. In such terrain the tail is a valuable aid, supporting and balancing the little reptile as it climbs and runs about the grass tops in search of insect prey. Presumably because of its importance to the reptile, the tail is parted with less readily by a six-lined lizard than by many of its relatives.

In addition to the extraordinary tail, the rather unusual scaling of this lizard should assist in recognizing it. The entire back is protected by lines of large plates arranged in from four to six rows. The middle pair is brown to bronzy green, while the outer ones carry a pure white line edged above and below with deep black. In females the colors are duller and less sharply contrasted than in the handsome males. Some of the latter display white, black-edged, eye-like spots on the flanks. These flanks are covered with numerous tiny, almost granular scales which are very different from the back plates or the relatively large and strongly ridged, sharply pointed, greenish white belly scales that form ten rows across the stomach region.

During April and May in Java, the female lizards deposit from two to three eggs on the ground, usually about the base of a tussock of grass. The eggs, covered with a white and parchment-like shell, are slightly less than ½ inch in length and about ¼ inch in breadth. A hatchling emerging late in May measured 3⅜ inches, rather more than 2¼ inches being tail. If the lizard grew to the maximum for this species it would be 14½ inches, of which total no less than 12 inches would be tail!

GECKOS

In the matter of discarding tails, few lizards can compete with the geckos. Some species are so prodigal in this respect that it is difficult to find one with original tail intact. Of the nearly 700 kinds of geckos, probably less than a dozen fail to make use of this defense.

The name gecko originated in early attempts to record the call notes of one of these lizards, variously transcribed as "checko," "tocktoo," "toki," "tok," or "chick, chick" for other members of the family. Possibly such sounds are produced by abruptly withdrawing the broad tongue (fig. 23) from the palate, but some geckos squeak when caught. These vocal attributes of geckos are unique among lizards, which, except for the hissing of monitors and others, are generally a silent group.

Another characteristic that singles geckos out from the majority of lizards is the female's ability to lay eggs with shells as hard and brittle as those of the crocodiles and tortoises. Geckos produce a pair of eggs, usually roundish, sometimes flattened on the side adhering to the bark, rock, or wall in the case of those species that attach their eggs to such objects. The only exception to this rule is a New Zealand gecko which reputedly gives birth to live young.

The global distribution of the family in warmer zones, together with certain anatomical characteristics, suggests that the geckos are an ancient group, and this they are usually conceded to be. The reduction in strength of skull elements, often to the thinness of paper, is a more recent development.

All geckos have well-developed limbs and most of them have five fingers and toes. The remarkable adaptations and structural diversity of these fingers and toes furnish the best means of recognition and classification of the numerous species, of which several score are to be found on Pacific islands. Even for a specialist it is not always easy to decide to which of a dozen genera some gecko should be assigned; consequently it seems extremely doubtful whether a key to distinguish them would serve a useful purpose in such a book as this. For most readers it will be enough to know that a certain lizard is a gecko, without going into minor, and often technical, differences as to genus and species.

What amazes most people upon seeing a gecko for the first time, is the creature's ability to run over a windowpane or up a smooth vertical wall and across a ceiling. Geckos with this ability have some part of their fingers and toes more or less dilated into disks. If one examines

the underside of these expansions, it will be seen that they bear a series of transversely broad, otherwise usually narrow, plates. It was long supposed that these "lamellæ," as they were called, when momentarily pressed against a smooth surface, produced vacua so that their united action supported the gecko's weight.

Militating against such a theory is the fact that they do not function on wet surfaces. Indeed, it seems probable that a water pistol is likely to prove the best weapon for securing a gecko alive and uninjured by causing it to fall to the ground. If the lamellæ operated on the principle of a suction cup, then a moderate amount of moisture might be expected to aid, rather than hinder, the creation of vacua. In attempting to arrive at a correct explanation, Professor B. Mahendra made numerous experiments which led him to conclude that the real factor was the microscopic hair-like processes which cover each lamella. Naturally, when damp these "hairs" become matted and fail to function, but when dry they are pressed into every minute inequality of the surface over which the gecko happens to be moving. By interlocking with these myriad inequalities, they provide supplementary support to that afforded by the gecko's sharp claws.

In some geckos the claws can be withdrawn into a sheath or between the terminal plates. A few non-Pacific forms are clawless. Such geckos are either ground-dwellers or if climbers, are compensated by having particularly well-developed "lamellæ" for which the word "scansors" seems apporpriate. In quite a number of Pacific geckos the "thumb" or inner toe is clawless; in others again even the inner digit itself may be reduced to a mere vestige or may be entirely lacking.

Unlike most lizards, the majority of geckos are nocturnal, as might be suspected from their cat-like vertical pupils. At dusk, however, a large orbicular pupil appears, exposed by retraction of the membranous diaphragm. One Pacific group (*Cnemaspis*) has round pupils but appears to be no more diurnal than the others. After a cold night even the nocturnal species like to creep from their retreats to bask for a time where the sun strikes the edge of some crack or cranny into which they can slip at the first suggestion of danger.

CAT GECKO

Most geckos are characterized by the absence of movable eyelids, the latter being reduced to a vestigial ring or semicircle. Two of the exceptions inhabit Borneo and Malacca; in these lizards both upper and lower eyelids are well developed and movable. The cat gecko, as the better known is rather aptly called, has long and spindly limbs and its fingers and toes lack expansions; its slightly swollen tail is rather carrot-shaped. The coloring is somewhat peculiar, for the brown back and tail bear dark-edged white spots or blotches. It attains a length of rather more than 6 inches. That is well above the average for a gecko, most of which measure about 3 or 4 inches, with only one kind exceeding a foot in length.

TOKAY GECKO

This largest species has a maximum head and body measurement of 7 inches, the tail being as much again if so large a specimen could be found with its tail intact. It also happens to be the first of the family to be described by Carl Linné in 1758 and is widely distributed throughout the Dutch East Indies and Philippines as well as on the Asiatic mainland. The *tokay*, as the Malays call it, has a head which is 1¾ inches long by 1¼ inches in breadth. The upper parts are covered with flattened granules among which are scattered numerous large, but usually flattened, tubercles. The scansors beneath its dilated digits form a single slightly wavy series, each narrow lamella extending across from side to side.

Above it is gray, or rather bluish gray, profusely spotted with brick-red and grayish white, the light spots often arranged in transverse rows. In young examples the tail is handsomely banded with dark blue and whitish, these colors becoming olive and pale gray with age.

The *tokay* appears to be one of the most vocal of lizards, though Flower tells us its loquacity is restricted to certain seasons. Beginning in the cooler December weather, their cries reach a maximum during

the hot season from March to May. The call begins with a preliminary cackle and is followed by "to-kay" or "tuk-kaa" repeated very distinctly half-a-dozen times or more; it concludes with a low gurgling sound. On a quiet night the call sounds so loud and clear that it can be heard plainly a hundred yards away. Sometimes the calls continue throughout the night, being taken up by gecko after gecko as they call to each other from room to room or house to house.

In some districts scarcely a house can be found which does not harbor at least one of these geckos. During daylight they remain concealed in crannies, emerging about sundown to scour the walls in search of insect prey, but fully prepared to attack any creature they are strong enough to overpower. Even mice, small birds, and snakes are said to be taken when opportunity offers, while the smaller house geckos are well advised to keep out of the way of their big relatives or pay with their lives. Each *tokay* has its regular beat or "sphere of influence" upon which others are not permitted to trespass.

If teased or cornered, a *tokay* will inflate its body and hiss or puff loudly as it holds its jaws wide open in readiness to attack. Malcolm Smith has seen such a lizard rush at the object of its annoyance, seize the person in its powerful jaws, and hang on with bulldog tenacity.

Snakes which prey on geckos find the *tokay* a difficult customer. One observer records a fight between a rat snake and a gecko that lasted for three hours and then ended only because the combatants were disturbed. Flower tells of a green and black tree snake 4 feet 9 inches long and a 12¼-inch gecko so occupied in a struggle that had already lasted several hours, that they permitted themselves to be picked up and carried into the house without relaxing their hold.

Naturally, many superstitions are current regarding such a lizard as the *tokay*. When a new house is built, the occupants anxiously await the arrival of the first *tokay*, venturing to predict something of their own future fortunes from the number of days that elapse before its appearance. Apparently the sooner it comes, the better are their prospects. Similarly it is a good omen for a *tokay* to call at the birth of a child; the oftener its cry is repeated, the better for the baby. Bets are laid on the number of calls a gecko will emit, so that the *tokay* unwittingly becomes an animated gambling device.

On the other hand, even some Europeans mistakenly believe that the bite of a *tokay* is fatal, or that the "suckers" on its feet will raise blisters. Such superstitions regarding geckos are as widespread as the harmless and beneficial little lizards themselves. Ignorant natives credit them with giving rise to leprosy by running over people when they are asleep. Food is allegedly poisoned if the gecko's feces fall upon it from the roof. They are accused of maliciously spewing back into water vessels from which they have drunk, so as to poison the fluid before they leave. The bite of one species is even said to leave its mark on steel! In reality, except for the *tokay* and a few of its large relatives, the tiny blunt teeth and feeble jaws of the majority of geckos are quite incapable of breaking the most tender human skin.

COMMON HOUSE GECKO

Commonest of all the house geckos to be found in the Indo-Australian archipelago is a little 5-inch fellow whose cry consists of a repetition of "tok, tok." In color this species is grayish or purplish brown indistinctly marked with darker shades, but a dark line along the side of the head is usually present and sometimes extends as far as the flank. The tail is ringed alternately with dark brown and yellow, or may be coral-red. Like most geckos, it exhibits considerable ability in changing its hue to match the background and one living on a whitewashed wall is likely to be very pale indeed. They are equally at home in gardens or open country and often establish themselves on boats and steamers. To this ready adaptability we can attribute their present erratic distribution at points so widely separated as Mexico, St. Helena, and Lamu Island.

In this last locality I have found both young and eggs among the spathes of young coconut palms. Each round white egg measured about ⅜ inch in diameter.

Taylor tells us that the *tiké* or *butiké*, as it is called in the Philippines, though common, is not quite so abundant as some other house geckos. As many as three species may be found living peaceably in one small room where each kind keeps to a more or less recognized area. Should two geckos happen to stalk the same moth or insect, a fight may result.

Combats are of brief duration, consisting of a bite or two accompanied by a few chirping cries, possibly followed by the discarding of a tail and the hasty departure of the vanquished.

The Filipinos do not fear but appreciate these lizards for their activities in keeping down moths, mosquitoes, cockroaches, and other pests. Should a gecko's discarded forked tail be found by a native, he considers himself lucky and carries it with him when attending a cockfight. The Tagalogs have a superstition that the geckos leave buildings at 6.30 P.M. to go and kiss the ground.

SAD GECKO

While the common house gecko has claws on all five fingers and toes, another, which has been christened *lugubris*, lacks a claw on the inner digits corresponding to thumb and big toe. This smaller house gecko never exceeds 3½ inches in total length, yet deserves mention if only on account of its abundance on Pacific islands from the Philippines to Honolulu.

One author, J. O. Snyder, tells of capturing 102 in the course of two hours. Many were found huddled in crevices and were removed one by one with the aid of forceps. Not until their number was seriously depleted did the remainder take fright and scatter. When lone individuals were followed to their new retreat, their behavior was most interesting. As the forceps approached, the gecko would move its tail to and fro, sometimes thrashing it about quite violently. One actually backed out towards the entrance of the crevice, deliberately presenting its wriggling tail to the foe. When the tail was seized it was instantly discarded by the gecko, which then flattened its body and remained motionless as if expecting to avoid detection now that the enemy was occupied with the writhing tail.

A captured gecko is likely to emit a faint squeak. The usual cry when hunting at night is a shrill, cricket-like sound, so high pitched that not all human ears can pick it up. If two geckos happen to meet in the course of their forays, they will give a sharp chirp and momentarily touch noses. The sad gecko lays its eggs, measuring only ⅜ by

¼ inch, in cracks of boards, posts or trees, in clumps of leaves, under loose bark or rocks, behind books and picture frames, or even stuck to vertical surfaces. On hatching, the little gecko is wet but dries so that its delicate epidermis—like white tissue-paper—bubbles, comes loose, and flakes off in ragged scraps to reveal the fresh skin beneath. This is delicately marked in the grays, browns, and yellows of the adults, which are as changeable as other members of the family.

"FLYING" GECKOS

Before turning to the agamids, mention should be made of the fringed geckos of which four species are known, one from the Philippines and two from the Dutch East Indies. These lizards are likely to arouse interest on account of the skin expansions which at one time caused them to be known as "flying geckos," because of a native's report that he had caught one as it was "flying" from one tree trunk to another. Malcolm Smith suggests that in a wind the membranes might serve to increase the lizards' buoyancy, for apparently no muscular development exists that might enable the gecko to expand them. Both N. Annandale and T. Barbour have noted that the membranes were not employed for parachute purposes by geckos dropped from a moderate height or teased into leaping from a table.

Their function or purpose can be settled only by careful observers noting their behavior in a wild state. The suggestion that the flaps might be an aid to adhesion can be definitely rejected. More plausible is the idea that they serve to disrupt the outline of these mottled brown and gray lizards so that they merge into the background of bark and are rendered even less conspicuous than they already are.

KUHL'S FRINGED GECKO

In Kuhl's fringed gecko, common on Java, there is an extensive flap on each jowl just below the ear-opening; when wrapped about the base of the jaws, this flap may well escape notice. In addition to the main flaps on either side, which differ from those of the "flying lizards" in being unattached to the limbs and unsupported by ribs, each

limb has expansions and the fingers and toes are webbed almost to their tips. Strangest of all is the tail whose scalloped side expansions and broadened end conspire to make it more like some queer leaf. If this original tail is lost, the regrown one will lack the strongly crenulated outline, the edge of the new tail being very nearly even.

Kuhl's gecko deposits its eggs on the undersurface of leaves or in fissures of the rough-barked trees on which this lizard lives. Each of the pair of eggs, cemented to its fellow so as to form a figure 8, measures ½ inch in diameter and rather less in depth, as the lower side is flattened at its point of attachment. In Java the incubation period is said to last five months (November to May). Upon hatching, the young immediately set to work to divest themselves of their delicate white scarf skin by rubbing against sticks or pulling it off with their jaws and then devouring it. One young one under observation for two weeks invariably kept its body expansions closely applied to its trunk.

HORSEFIELD'S FRINGED GECKO

In Javanese Kuhl's gecko is called *ular papatek*, though *ular*, Barbour tells us, is usually restricted to snakes. The closely related Horsefield's fringed gecko of Sumatra and Borneo has its back covered with uniform granules, in which respect it differs from Kuhl's gecko, which has enlarged tubercles scattered among the granules. The third species, known only from Mindanao in the Philippine Islands, has even more tubercles and a somewhat different tail.

AGAMA LIZARDS

Agama or agamid are the names given to a remarkably diversified group of Old-World lizards which present their maximum variety in the Oriental region. Agamids are absent from New Zealand and Micronesia,[1] while in the Galápagos, Americas, and Madagascar their niche is filled by iguanids. The only character which serves to separate all agamids from the other lizards of the Pacific region is that of denti-

[1] Their reported occurrence in the Fijis and Tongas requires confirmation.

tion cited in the key. Though all agree in having the teeth attached to the summit of the jaws (fig. 24), the teeth themselves show much diversity but can usually be separated into types resembling incisors, canines, and molars.

Agamids, unlike the majority of geckos, have well-developed eyelids; the eyes themselves are of moderate size with round pupils. Eardrums are either exposed or concealed beneath the skin, and the top of the head is covered with small scales instead of large symmetrical shields. As might be expected, those forms which live in trees have compressed bodies, while among the ground-dwellers they are more or less depressed. Not only is the tail usually long and not brittle, but in at least one Sumatran lizard it is actually prehensile; some agamids can reproduce a tail if it should get broken in a fight.

Many species are provided with ornamental crests, frills, or throat pouches, or these adornments may be restricted to the males. In a few groups the males, and occasionally the females also, have a row of perforated scales in front of the anus or on the underside of the thighs (fig. 30). These are known as preanal or femoral pores, and their purpose is to secrete a waxy substance that leaves a scented trail.

While most agamids are insectivorous, some kinds prefer a mixed diet, and others again subsist on leaves, flowers, and fruits. Unfortunately, neither diet nor habitat is any help in classifying these lizards, which are often difficult to distinguish because the young differ from the adults. It is hoped, however, that the following key may prove of some assistance in showing to what group or genus an agamid belongs. Since few of these genera have English names, I have supplied the deficiency, in most cases by translating the generic one.

Key to the Genera of Agamid Lizards in the Pacific[1]

1. No pores on hind limb 2

   Pores present on hind limb (fig. 30), at least in males 14

[1] Ranges extending to Asiatic or Australian mainlands not included.

2. Ribs much prolonged to support a wing-like expansion of skin on flanks (fig. 2); range: Hainan and Philippines south to Sumatra and Timor ..... flying lizards (*Draco*)

   No wing-like expansion of skin on flanks .. 3

3. Eardrum concealed 4

   Eardrum distinct 8

4. No crest on back; scales small intermixed with large conical tubercles; range: Borneo; Sumatra eyebrowed lizards (*Phoxophrys*)

   A crest along back, even though a mere denticulation 5

5. Tail prehensile; end of snout terminating in an erect scale or group of scales, at least in males 6

   Tail not prehensile; scales on back small, uniform or intermixed with larger ones 7

6. Scales on back very large and irregular; a slight skin fold across throat; range: Sumatra;

8. Snout ending in a horn-like appendage 9

   Snout without any terminal appendage 10

9. Snout appendage compressed; scales on back not keeled; male without gular sac; range: Nias; Sumatra; Java ..... nose-horned lizards (*Harpesaurus*)

   Snout appendage not compressed; scales on back keeled; male with a small gular sac; range: Sumatra ..... Brook's lizard (*Thaumatorhynchus*)

10. No crest on neck or back; 1 or 2 pairs of pores in front of anus, sometimes absent in females; range: New Guinea ..... two-pored lizards (*Diporophora*)

    A crest along back, though a mere denticulation in *Dendragama* 11

11. No skin fold across throat; males with a gular sac 12

    A strong fold across or almost across throat .. 13

12. Scales on back unequal; range: Sumatra; Java tree agamas (*Dendragama*)

    Scales on back uniform; range: Philippines; Borneo; East Indies, etc. ..... variable lizards (*Calotes*)

13. Scales on back uniform; digits not keeled below; males without a gular sac; range: Sumatra ..... crested lizard (*Lophocalotes*)

    Scales on back unequal; digits keeled below; males with or without a gular sac; range: Philippines and Sumatra east to Polynesia .. angleheads (*Gonocephalus*)

14. Body depressed; no crest on back; skin on

	sides expansible; tail round; range: Sumatra; Banka	granular-scaled lizard (*Leiolepis*)
	Body and tail compressed; skin on sides not exceptionally slack	15
15.	Neck bearing a large distensible skin collar	frilled lizard (*Chlamydosaurus*)
	Neck without a collar	16
16.	Tail strongly compressed and bearing a high crest; toes edged with lobes; range: Philippines and eastern East Indies to New Guinea	sail-tailed lizards (*Hydrosaurus*)
	Tail rounded or slightly compressed with at most a low serration; toes with serrated edges; range: Timor Laut; Kei Islands; New Guinea	water lizards (*Physignathus*)

FLYING LIZARDS

The flying lizards (fig. 2), of which about forty kinds have been described, may be distinguished immediately by the wing-like expansions of skin on either flank supported by half-a-dozen of the hindmost ribs. The ribs function in much the same manner as those of a parasol, for when the lizard does not require the expansion it presses the ribs against its sides so that the expansion folds up with them and becomes scarcely noticeable. The expansions are in the nature of parachutes and are not used to beat the air as do true wings.

When a flying lizard is resting in its customary vertical position on a tree trunk, the mottled brown and gray coloring renders it inconspicuous. Only its eyes keep moving as it constantly focuses them on passing insects till one approaches within range. Then suddenly spreading its "wings," the nimble lizard leaps into the air and with unerring aim seizes the prey. So rapidly do these agile little reptiles open and close their "wings" as they spring from branch to branch

that the action is scarcely noticeable. Major Flower observed one lizard glide smoothly and steadily for a distance of 60 feet before adroitly landing on all fours as it closed its parachute and settled upon a tree trunk. Some kept on board a ship were in the habit of planing from one table leg to another.

The best-known species is the Malay flying lizard, which is not only found on the mainland but in the Philippines occurs on Palawan, southwards through Borneo to Sumatra, Java, and other islands. The coloring of this lizard in life is said to be so beautiful as to defy description. The upper parts are brilliantly metallic varied by wavy crossbars and small dark spots; in particular there is one black spot between the eyes and another on the nape. The throat is mottled with black; the parachute is orange marbled or streaked with black, the black spots on its underside being especially characteristic of this species, which has a total length of 8 inches.

It is also characterized by having the nostril lateral and directed outwards, the ear-opening smaller than the eye-opening, and no spine above the eye. The males have a small crest on the nape in addition to a large membranous dewlap on the throat, which is erected and inflated under the stimulus of excitement. This appendage is orange in males and green or bluish in females, though less conspicuous.

As they lie basking amid the gorgeous flowers and luxuriant vegetation of the tropical forest, these lizards have a trick of opening and closing their beautiful "wings" in the manner of butterflies. K. P. Schmidt, who observed a male flying lizard doing this in the Celebes, concluded that it was a courtship display. The color patterns on these expansions often differ as between the sexes but are fairly constant within each species, so that they provide a useful aid to identification.

Dr. Malcolm Smith has published an eyewitness' account of a fight which took place between two males of a Siamese species. Several times one or the other of the combatants lost his hold and fell for some distance with membranes spread before alighting and returning to the attack. From time to time a third lizard, which was on the farther side of the trunk, put its head around to see how the fight was progressing. In all probability this was a female, as the combatants were

indisputably males. Dr. Smith believes that after pairing, male and female remain together for the rest of the season.

These essentially arboreal lizards dwell in the forest canopy and rarely descend except when the females do so to bury their oval eggs in the ground. These eggs are covered with a soft, parchment-like shell, and a batch consists of from two to five eggs.

PREHENSILE-TAILED LIZARD

The deaf or prehensile-tailed lizard of Sumatra deserves passing notice if only on account of its rarity; only two specimens are known. In males the end of the nose bears a single horn-like scale, while a series of enlarged scales forms a crest along back and tail. Otherwise this brownish lizard is covered with irregular large scales. Together with a relative in Ceylon, which is the only agamid known to give birth to live young, it long shared the distinction of being the sole member of the family to have developed a prehensile tail as an aid in arboreal adventures. More recently another agamid has been found that is thought to be similarly equipped. While the tail of the Sumatra species is 4 inches long, the head and body together measure only 3 inches.

NOSE-HORNED LIZARDS

As rare, and even more striking, are the nose-horned agamids, each of the three kinds being known only from a single example. The one found on Nias Island has no crest on the back but there is a single horn-like scale on the end of the snout. The Javan species has a crest as well as a "horn," while the Sumatra lizard possesses two long "horns" in addition to a crest. Not one of these three species appears to be represented in any American museum.

JAPALURES

From Japan south to the Natunas and Borneo, the place of these lizards seems to be taken by the better-known agamids called japalures.

One Bornean species has a very short appendage on its snout; the rest have no such adornment.

"CHAMELEON"

On account of their ability to change color, certain agamids are commonly called "chameleons" by East Indians. In reality these lizards belong to the genus *Calotes*, which has nearly a dozen species on the islands. Several of these have a crest of sharp spines on the head and neck, the back covered with rough scales, and a whiplash tail two or three times as long as the body. Some species attain a total length of 23 inches but lizards of about half that length are more usually met.

VARIABLE LIZARD

The best-known kind, though rare on Sumatra, enjoys a very extensive distribution on the mainland, where its name of "bloodsucker" probably had its origin in superstitious beliefs. More appropriate is "variable lizard" from the rapidity with which it changes color under stress of emotion or when basking in the sun, an ability which makes brief description difficult. The head and neck are frequently yellow flecked with red, the body red, the limbs and tail black. The head and shoulders of a courting male may become brilliant scarlet with or without black blotches on cheeks, neck, and throat; sometimes the scarlet covers most of the body except for the more intensified spotting.

The courtship has been described by Annandale, who says that the male selects some conspicuous spot and advances towards the female, which remains concealed in the nearby foliage. Then raising the forepart of his body as high as possible, while distending his gular pouch to the utmost so as to display the black spot, he rapidly opens and closes his mouth as he solemnly nods his head up and down. Should another male appear, a fight will develop, for these lizards are decidedly pugnacious. During the fight color changes take place rapidly, and if one of the combatants is driven away, caught, or killed, the

black spot on his neck will entirely disappear. It should be added that the gular pouch is a small one and is developed by the male only during the breeding season.

The breeding season commences in May, and eggs are laid during the four succeeding months. These eggs apparently vary both in size and as to the number produced in different parts of the "bloodsucker's" range. Some are about 3/8 by 1/4 inch, others as much as 5/8 by 3/8 inch, while numbers vary from four to twenty-three. Reports are conflicting as to the depth of the hole the mother digs for their reception; some observers find them only a couple of inches below the surface, another at 6 or 7 inches in soft earth. On the mainland the variable lizard is found on bushes or hedges, both in gardens and open jungle, where it feeds principally on insects and spiders but has been known to devour nestling birds.

ANGLEHEADS

More widespread are the thirty-odd kinds of angleheads, though on the islands they do not occur north of the Philippines. When an anglehead lizard is disturbed in thick jungle, it runs away along the ground instead of taking to the trees, so that it must be considered terrestrial rather than arboreal. In rocky timbered country on the Asiatic mainland, one species was observed habitually to seek refuge in crevices of the rocks and to ignore the trees. As members of this group are not very swift, they can be captured with relative ease. Some that habitually sleep in hollow trees or beneath logs, remain perfectly quiet when exposed, seeming to rely on their neutral coloring to escape detection. When angered, the male of one kind inflated its throat. Most of the species change color rather readily. In size they range from about a foot to 16 inches, with the tail decidedly longer than the body. Their food consists of insects, grubs, and worms.

FRILLED LIZARD

With the exception of the flying lizards, no agamids have produced so strange an adornment as the frilled lizard of New Guinea and Aus-

tralia. There is no mistaking this creature for any other lizard in the world. Though averaging only 2 feet in total length, a male can erect a frill measuring 9 inches in diameter. When the wearer is undisturbed, this frill-like skin lies in neatly folded symmetrical pleats about its neck. If approached by a potential enemy such as a man or dog, the lizard gapes its widest as simultaneously it erects the frill with the suddenness of an opening umbrella. The bright coloring of the frill as it stands out at right angles to the neck, and the menacing aspect of the widely opened mouth, combine to present a threatening and formidable appearance. Many a dog accustomed to chasing and killing the larger monitors, is likely to retire discomfited when confronted by a frilled lizard. The imposing frill, which might be compared to an Elizabethan ruff, is chiefly orange and chrome-yellow splashed and speckled with bright scarlet. Thus it presents a striking contrast to the neutral-toned, light brown body with its more or less distinct darker bars or reticulations.

Though normally proceeding on all fours like most lizards, when fleeing in open country the frilled species' mode of progression is little short of astonishing. Assuming a semi-erect and grotesquely human posture, it races away on its hind legs. Even the variable lizard has been known to adopt bipedal locomotion under great stress, as do several American lizards with less provocation. This is of interest when one recalls that the footprints of certain extinct dinosaurs reveal that they normally proceeded on their hind feet only—an interesting parallel development by groups which are but distantly related.

This mode of travel is carried even further in the tropical American iguanids known as basilisks and in the agamid sail-tailed lizards. In having the enormously long toes of their hind feet expanded and flattened along the sides, basilisks show a resemblance to the sail-tailed lizards, in which this characteristic reaches an even greater degree of development. Members of both these groups run erect across the surface of a stream.

SAIL-TAILED LIZARD

The sail-tailed lizard is to be found from the Philippines south to Celebes and New Guinea with insular races on the various groups of islands. This big lizard, reaching a length of more than 3½ feet, not only has a series of serrated scales forming a crest on nape and back, but the tail, which comprises two-thirds of the total length, may be as much as 4 inches high owing to the great development of a skinny crest that is supported by long spine-like projections of the tail vertebræ. In females this caudal crest is much lower.

As their scientific name suggests, sail-tailed lizards are semi-aquatic, swimming well and diving under water for a minute or more at a time. Like the monitors, they lay their eggs in the banks of the rivers and climb among the fringing trees to feed upon the leaves. In the Philippines these lizards are called *balubid* (Tagalog), *huniango* (Ilocano), and *ibid* (Visayan) by the tribes named. Taylor tells us that the people hunt them for their flesh, which is highly esteemed as an article of food.

LESUEUR'S WATER LIZARD

Agreeing with both the foregoing reptiles in bipedal locomotion, Lesueur's water lizard of New Guinea and Australia is the agamid most likely to be mistaken for an iguana. The similarity lies in the strong serrated crest of scales on its nape, less pronounced on the back, and its large size, for this water lizard attains a length of 4 feet. Like the monitors, it favors scrub in the vicinity of rivers, but is even more aquatic, for it likes to pass the time in shallow water with only its nostrils raised above the surface. During spells of hot weather captive specimens chose to spend the nights in their water tanks. An expert swimmer, Lesueur's lizard propels itself with speed and grace by means of its long and laterally compressed tail. These lizards do rather well in captivity, for fourteen of them in the London Zoo had an average length of life of four years and eight months, while Flower tells us that a water lizard in Dublin Zoo lived for six years.

IGUANIDS

It will be recalled that the only way to distinguish an agamid from an iguanid is by the teeth, which in iguanas are attached to the inner side of the jaw. This may not sound very helpful, so it is fortunate that in the Pacific there is probably no overlapping of ranges and hence little likelihood of confusion, for iguanids are found only on the Fijis, Tongas, and Galápagos, insular groups on which agamids are probably lacking.

MARINE IGUANAS

When the first men landed on the Galápagos a marvelous spectacle met their astonished gaze. Big marine iguanas swarmed along the rocky coasts as numerous as people on Manhattan beaches during a heat wave. Even so recently as 1902, tangible evidence of this abundance was obtained by R. J. Beck, who secured photographs of some acres of lava all but concealed by a drove of iguanas. While previously their numbers were largely attributable to the absence of enemies, undoubtedly their adaptation to a seaweed diet has played no small part, for their chosen food is plentiful around the shores of their island home. The lizards do not have to dive to obtain the algæ but at low tide enter the surf where its growth is most luxuriant, and there gorge upon the glutinous weed. While feeding, the reptiles may be inundated to a depth of several feet by the surging tide. Undaunted, the big iguanas anchor themselves so securely by their powerful claws that it is doubtful if any backwash ever dislodges them. Apparently they feed but once every twenty-four hours, for even on moonlight nights William Beebe never saw one taking advantage of a low tide.

On a calm morning it is not unusual to see a solitary iguana swimming from point to point across the still waters of some quiet cove. In such an enterprise the strong limbs play no part; the forelegs are held tight against the body and the hind ones trail out behind, as lateral undulations of body and tail propel the reptile steadily forwards. On reaching shallow water, the hind limbs aid the swimmer by kicking against the rocky bottom.

Though marine iguanas are so much at home in the water, various investigators have found it impossible to drive them into it. When thrown into heavy surf they invariably dived to the bottom and then walked shorewards, clinging on with their claws when the suction of some big wave threatened to drag them out to sea. Perhaps a dislike of struggling against turbulent breakers makes the lizards refuse to be driven into the surf, while it has been suggested that a fear of sharks may account for their reluctance to be herded off a beach.

Beebe reports marine iguanas as abundant on every type of shore, but their black coloring and rugged outlines blend best with the black lava rocks in whose crevices they sleep. Any attempt to withdraw an iguana from its retreat was resisted stoutly. If seized by the compressed and crested tail—and their tails are of the toughest—the lizard inflated its lungs to the utmost, so that every possible scale pressed against the rough sides of its refuge and formed a useful supplement to the score of strong claws which found a purchase in the irregularities of the lava.

It soon became apparent that such methods were not necessary to effect a capture, for the creatures were so tame that when an old iguana crawled out to bask alongside Beebe, he leaned over to scrawl the lizard's own initials—A. c.—on its scaly hide. If the basking lizards are approached cautiously on all fours, so as to show some resemblance to the harmless sea lions with which they are familiar, it is possible to stroke their wrinkled skins. To capture them in numbers for the New York Zoological Gardens, however, nooses dangling from the ends of fishing poles were employed. By this means four persons secured forty iguanas in the course of an afternoon. Beebe tells of noosing in succession all three lizards comprising a group basking upon a single rock. As their companion was swung into the air, the second and third reptiles showed no fear whatsoever and merely exhibited a mild curiosity!

Intrigued by this indifference, Beebe decided to test whether the reptiles were capable of fear. Noosing one, he swung it about for some minutes, then released it. The lizard only ran a few feet, then looked back, and offered no resistance to being noosed again and

again. After the sixth noosing it appeared, if anything, to be tamer than at the beginning of the experiment.

Marine iguanas exhibit the same fearlessness in their relations with other creatures, for they crawl over slumbering sea lions as casually as over a rock. When a photograph was being made of one reptile, a large red crab came sidling over the rocks and climbed over the lizard's head. The reptile's sole reaction was to close its eyes in deference to the crab's sharp limbs. On went the crab, pausing from time to time to pluck a tick from the reptile's hide, and though it pulled hard on the skin the iguana showed complete indifference. One lazy lizard crawled between the tripod legs and fell asleep.

For all their size—individuals attain a length of 4½ feet and a weight of 20 pounds—marine iguanas make no use of teeth or tail in self-defense. Only the claws of a struggling captive may involuntarily inflict severe scratches on restraining hands. At times, it is true, they bite one another, but not severely. Karl P. Schmidt noted that each male kept to his own sunning terrain, usually from 5 to 10 feet from that of the next male. A fight invariably resulted when one lizard trespassed on the territory of his neighbor. Fights consisted in butting, and each lizard attempting to get the horny knobs on his forehead under his adversary's chin. The longest fight observed by Schmidt lasted only four minutes. After a fight the spray blown from the nostrils of the combatants was blood-stained, showing that some injury resulted from the vigorous butting. Prior to a fight an old male might challenge his rival by rising high on his forelimbs as both bobbed their heads and discharged watery vapor from their nostrils. This demonstration sufficed, and upon its conclusion each animal went about its separate business.

Courtship consists of a similar head bobbing and must be an entertaining spectacle when one considers the lizard's prehistoric appearance and bulldog mien. Edmund Heller tells us that eggs are laid toward the close of the rainy season in holes excavated in boulder-strewn sandy areas. The soft-shelled, oval eggs in one nest measured about 3 by 1½ inches, and were six in number.

The young are brown, spotted with paler brown and with dark bars

across the back. While the adults, as already stated, are usually black or blackish brown, they may assume brighter colors during the breeding season, for on Hood Island in February Heller noted that they showed green and red as well as black. On Chatham Island he found that the natives who had settled there had all but exterminated the marine iguanas, for it did not take mankind long to discover that however repulsive-looking the reptiles might be, they were good to eat. Elsewhere, though still common, their numbers appear to be dwindling. Attempts to keep them in captivity have proved a failure, as the big lizards refuse to feed and I know of none surviving more than eighteen months.

LAND IGUANA

While the very nature of their restricted diet confines the marine iguanas to the fringing shores, inland on the Galápagos one finds the closely related land iguanas. The form on Barrington Island has a dorsal crest higher than that of other land iguanas, while the terminal scale on its snout is not less than twice as broad as high, instead of one and a half times as in the commoner type.

In color the land iguana varies considerably. The head may be light yellow, the body olive or bright brick-red like the lava of the uplands, and the belly and undersurface of the limbs are yellow. Land iguanas are more stockily built than the marine species, the tail is stumpier and the total length nearly a foot shorter. As to weight, adults may be expected to tip the scales somewhere between 10 and 15 pounds. The spiny crest on the nape is not so high as in the marine iguana and dwindles to a low serration along the back.

So abundant were these lizards on James Island at the time of Charles Darwin's visit (1835) that it was not easy to find a spot free of their burrows on which to pitch a tent. Yet of the same island Heller could write in 1906: "No iguanas were seen, but I found some bones in a crack in the lava." On Albemarle a few survivors were encountered, though Heller estimated by the number of burrows that formerly there must have been as many as 1,000 lizards in the Tagus Cove colony alone.

The burrows are usually made on level stretches of the soft sandstone-like tufa, though occasionally one may be found between fragments of lava. Because of the gentle angle of excavation, the burrows are a nuisance to the weary pedestrian whose feet constantly break through the thin crust of covering soil. Darwin observed that in digging its burrow, an iguana used first one forefoot and then the other, the scratched-up soil being thrown towards the corresponding hind foot which heaved it from the entrance. None of the burrows were very deep.

On Narborough Island, where land iguanas were still plentiful in 1906, they rarely resorted to burrowing and the great majority resided in fissures in the lava. From these retreats they did not venture far and rushed back to them when alarmed. Actually land iguanas are not timid and normally allow strangers to approach within 10 feet or so. They evince curiosity with curling tails or challenge the intruder with bobbing heads as they rise on stiff forelegs. Darwin discovered that by merely stamping on the ground he was able to cause them to drop this assumed boldness and retreat.

However, unlike their semiaquatic relatives, freshly captured land iguanas make good use of their teeth, biting anything that comes within reach and even biting each other savagely when several captives were placed together. Beebe records that one actually chewed through shoe leather. When he and his colleagues sat down to rest after trussing five of the iguanas, a number of mocking-birds descended on the helpless lizards and started to de-tick them, putting their heads under armpits or plucking ticks from between reptilian toes.

Essentially a herbivorous species, the land iguanas on Narborough Island eat principally a low plant called *Scalesia.* They also like the succulent cactus branches that are occasionally broken off by high winds. Darwin found entertainment in tossing a branch among a group of iguanas so as to watch their efforts to seize and carry it off "like so many hungry dogs with a bone." Not merely the branches but the flowers and fruit of the cactus are taken, and Beebe tells of watching one reptile reach up and deliberately strike a fruit with its paw, only to have it seized by an alert companion when it fell.

Stranger still, he found these lizards eating the spines of *Opuntia* together with the pads, and remarks: "How it is possible for any creature to swallow such needle-length and steel hard spines and not perish, I cannot conceive." Yet their droppings are often a mass of full-length spines. Wherever the droppings of these lizards had fallen and disintegrated, *Opuntia* seedlings were observed to be growing strongly, showing the useful part the reptiles play in seed dissemination.

Their eggs are laid in the burrows and may measure as much as 3¼ by 2 inches; seven were found in one Barrington Island female and ten in another.

KEEL-TAILED LIZARDS

In marked contrast to the big indolent iguanas are their small and active relatives, the keel-tailed or lava lizards; of these there are a dozen kinds on the Galápagos and more upon the mainland of South America. Less than a foot in length, of which the greater part is tail, they are as timid as lizards anywhere, for they are preyed upon by the Galápagos hawk. It is not surprising, therefore, to find that the tails of these lizards are fragile and quickly parted with when circumstances warrant.

To describe the beautiful coloring of more than one species would take too long, but both male and female must be mentioned, as they are so entirely different. The male Albemarle keel-tail is olive-brown above, flecked with greenish gray and spotted with deep black about the shoulders. The serrations of its crest, like the cheeks, are mottled blue-gray and black; there is some rich red on the sides of throat and neck but the throat is largely deep black. The breast is chrome-yellow spotted with black, the belly greenish gray edged with brick-red towards the flanks. Females vary considerably as between island and island, and everywhere assume much brighter coloring during the breeding season when they may have a golden brown crown, olive-green back, scarlet cheeks and neck in rich contrast to a deep black blotch just in front of the shoulder; the throat is yellowish with dusky spotting.

Beebe saw one of these small scarlet-faced females dash up on the back of a big land iguana, whereupon both reptiles began bobbing their heads. The breeding season is in May and June; during those months females were often seen digging short sloping tunnels, presumably for the reception of the white and oval eggs which number from four to six. While the Bindloe Island species appears to be wholly vegetarian, living on seed capsules, blossoms, and berries, most kinds are omnivorous, with plant products forming but one item in a diet which includes beetles, caterpillars, grubs, grasshoppers, moths, land snails, and even an occasional crustacean.

BANDED IGUANA

On the Fiji and Tonga Islands is a tree-dwelling lizard which more closely conforms to most people's idea of what an iguana should look like than any of the foregoing members of the family. Though the beautiful banded iguana was not uncommon as recently as 1915, it must now be considered rare, if not extinct, on many of the islands. Of its total length of 3 feet, quite two-thirds is tapering tail. Only the male merits the name of banded iguana for the female is of a uniform light green throughout. The male, on the other hand, has both body and tail alternately banded with rich emerald-green and pale gray; about his eyes and lips are lines of brightest yellow, while his throat pouch is almost pure white.

The following summary will provide a sound basis for distinguishing the iguanid groups to be found in the Pacific.

Key to the Genera of Iguanid Lizards in the Pacific[1]

1. No pores on hind limb; size small; tail fragile; range: Galápagos ..... keel-tailed iguanids (*Tropidurus*)

   Pores present on hind limb (fig. 30); size large (3 feet or over when adult); tail strong 2

[1] Ranges extend to South American mainland only in case of *Tropidurus*.

2. Pores number 10 to 15 on each hind limb; cheek teeth tricuspid; male with a throat pouch; range: Fijis and Tongas ..... banded iguana (*Brachylophus*)

   Pores number 17 to 30 on each hind limb; cheek teeth trilobate; male without a throat pouch; range: Galápagos 3

3. Tail roundish, slightly compressed; toes quite free; habitat inland ..... land iguana (*Conolophus*)

   Tail strongly compressed, crested; a trace of web between toes; habitat coastal ..... marine iguana (*Amblyrhynchus*)

SKINK FAMILY

Though for the most part of small size, members of the skink family merit some notice if only on account of their almost world-wide distribution. Of the 600 known species, 300 occur in the Pacific region if we include Australia. In Australia, where they may have originated, they are more numerous in species than all the other kinds of lizards put together.

The small size and highly polished scaling of the majority are connected with secretive ways and semi-burrowing or burrowing habits. Such skinks are usually found under drifts of dead leaves, piles of coconut husks, rotting vegetation, or decaying logs. Upon being disturbed, the skink will press its limbs close to its sides and literally sink into the sand or dusty soil with a wriggling motion which is like swimming as practiced by an eel. These habits have resulted in short limbs, reduction in number of toes, and in some instances even in complete loss of limbs.

Under these conditions it is natural that the eyes of skinks require protecting from sand or dirt every bit as much as do those of snakes. So we not only find that most skinks have well-developed eyelids, but some have a transparent window in the lower lid enabling the lizard to see even when the lower lid is tightly shut. The most extreme de-

velopment along this line is provided by the active little snake-eyed skinks, for their eyelids are wholly transparent and immovable, permanently covering the eye like a watch-glass.

By no means all skinks are terrestrial; a few are good swimmers, some are rock-dwellers, and others tree-climbers. The last often have long toes bearing numerous transverse plates, possibly of some slight assistance to the climbing skink and reminding one of the more highly developed scansors on the toes of geckos.

No doubt their small size and secretive ways are the principal reasons why we know so little of the habits of skinks as compared with larger and more spectacular lizards. So in the life histories of Pacific skinks lies a great opportunity for original observations and careful research. Though some of these skinks have a wide distribution, owing to the ease with which they are transported from island to island with garden produce or ballast, the more remote isles often possess species not to be found elsewhere. So no group is as likely to yield new and undescribed forms to the collector.

KEY TO THE GENERA OF SCINCID LIZARDS IN THE PACIFIC[1]

1. Eardrum exposed and near the surface 2

   Eardrum more or less deeply sunk or entirely concealed beneath the skin 3

2. Head covered with bony shields and distinct from neck; at least 1 row of greatly enlarged and strongly keeled scales along the back; range: New Guinea and Solomons ..... spiny-tailed skinks (*Tribolonotus*)

   Head normal and merging into neck; scales strongly keeled or smooth; range: Philippines and Borneo ..... waterside skinks (*Tropidophorus*)

3. Palatine bones in contact on the median line of the palate (fig. 26) 4

[1] Ranges extending beyond the Pacific islands not included.

Palatine bones separated on the median line of the palate (fig. 27) 12

4. Pterygoid bones separated on the median line of the palate, the palatal notch extending in front to an imaginary line connecting the centers of the eyes (fig. 26) 5

Pterygoid bones in contact (at least in front) about their middle, the palatal notch not extending forward as far as an imaginary line connecting the centers of the eyes (fig. 28) . 6

5. No supranasal shields; cheek teeth with blunt or rounded crowns; size large; range: Sumatra east to New Guinea and Moratau Island .... giant skinks (*Tiliqua*)

Supranasal shields present (fig. 29); cheek teeth cone-shaped; size relatively small; range: Japan southwest to Sumatra and New Guinea mabouyas (*Mabuya*)

6. Eyelids immovable, transparent, covering the eye; range: Bonin Islands south and east to most Pacific islands especially those with rocky foreshores ..... snake-eyed skinks (*Ablepharus*)

Eyelids movable 7

7. Supranasal shields present (fig. 29) except in *Dasia smaragdina* where they may be partially or wholly united with the nasal 8

Supranasal shields absent 11

8. Limbs short or vestigial; lower eyelid scaly or with a transparent disk; preanal shields present (fig. 34) or absent (fig. 32); range:

	Philippines southwest to Sumatra east to the Tongas	sand skinks (*Riopa*)
	Limbs well developed with 5 toes 9	
9.	Lower eyelid with a transparent disk; range: Philippines and Borneo east to Solomons and Society Islands	emos (*Emoia*)
	Lower eyelid scaly 10	
10.	No enlarged preanal scales; range: Philippines and Sumatra east to Hawaiian Islands	tree skinks (*Dasia*)
	A pair of enlarged preanal scales; range: Philippines and Sumatra east to the Solomons	eared skinks[1] (*Otosaurus*)
11.	Frontal shield neither constricted nor divided in middle; parietal shields present (fig. 29); limbs present or absent; range: Japan southwest to Sumatra east to Hawaiian Islands	supple skinks (*Lygosoma*)
	Frontal shield constricted or divided in the middle; parietal shields absent; limbs present; range: Luchus and Hainan Island	unarmoured skink (*Ateuchosaurus*)
12.	No supranasal shields; tail prehensile; range: Solomons	prehensile-tailed skink (*Corucia*)
	Supranasal shields present (fig. 29); tail not prehensile 13	
13.	Limbs well developed with 5 toes; nostril pierced in the nasal shield; range: Japan and Luchu Islands	long skinks (*Eumeces*)

[1] One species (*concinnatus*) links up with the *Sphenomorphus* section of *Lygosoma*.

Limbs short, vestigial, or absent; nostril pierced in a very small nasal shield between the snout shield, first lip shield, a supranasal, and sometimes a postnasal (see fig. 31 for names of shields); range: Philippines ..... Philippine skinks (*Brachymeles*)

SPINY-TAILED SKINKS

Least skink-like of all Pacific species are the four spiny-tailed skinks. Of these the most bizarre are the two New Guinea spiny-tails, for not only are their tails protected above and on the sides by spinose scales but such scales are so numerous on the back as to give it the appearance of being clothed in slightly hooked rose-bush thorns. The limbs, more especially the hind ones, are similarly protected, and even each scale of the undersurface carries a keel or rib. The triangular-shaped head appears to be in one solid piece with the roughly corrugated and indistinctly defined head scales. In coloration the head is rather darker than the reddish brown body, the underside somewhat paler, even yellowish. While the New Guinea forms are about 7 inches in total length, equally divided between body and tail, the Solomons species are only half that length and much less spiny. Nothing seems to be known of their habits, but recently attention has been drawn to pore-like pads on the feet of both New Guinea and Solomons species. This is an interesting point in view of the fact that no skinks have pores on the thighs, a character which helps to separate them from the typical lizards.

WATERSIDE SKINKS

Though the scientific name of the waterside skinks means "keel-bearing," a few kinds possess smooth scales on both head and body. It is interesting to note that the young of the smooth species actually have keeled scales, the keels disappearing with age. The young are born alive, and Taylor tells us that in the Philippines these lizards

should be sought for beside mountain brooks, but that on being disturbed they dive into the stream where they remain submerged for some time in order to elude capture. They feed on freshwater crustaceans as well as insects. In search of food they emerge from their retreats beneath stones or damp vegetation where they like to pass the hotter hours of the day.

GIANT SKINK

With a length just under 2 feet, the thick-bodied, shiny-scaled giant skink surpasses in size all other Pacific skinks except the prehensile-tailed skink of the Solomons. Its slate-gray to brownish yellow body is crossed by nine or ten dark bands. Though insects, young birds, and small mice are its food in a wild state, in captivity it employs its broad and purplish tongue to lap up eggs or finely chopped meat—a diet on which it thrives, for examples have lived in one zoo for nearly nine years. It gives birth to almost a dozen young.

PREHENSILE-TAILED SKINK

While the giant skink's tail is shorter than its head and body, that of the not dissimilar prehensile-tailed skink is considerably longer and is unique among skinks in its grasping ability. The scientific name *zebrata* was given to this species on account of the irregular dark brown stripes which cross the greenish white or olive-brown back; in some specimens, however, the dark bars disintegrate into blackish specks. Throat and belly are greenish white. An 18-inch prehensile-tailed skink was recovered from the stomach of an 11-foot crocodile in the Shortland group of the Solomons; others have been taken on Guadalcanar and San Cristoval, but nothing has been recorded of their habits.

MABOUYAS

The mabouyas, with less than half-a-dozen species in the Pacific, are a strong-limbed group of active lizards with representatives in Asia,

Africa, and tropical America. The most widely distributed form on the islands is the many-striped skink, which ranges from Sumatra to New Guinea. This is a slightly iridescent, olive-brown species usually appearing to have five black lines along the back, though quite uniformly colored examples are not uncommon. A race with slightly longer legs occurs in the Philippines and Borneo. From five to ten young are born at one time.

Yet another species of mabouya found on these islands lays eggs and deposits them among leaves or under the bark of fallen trees. In forested areas these skinks are exceedingly common; they bask on tree trunks and beside paths or rustle about in the undergrowth as they search for insects. According to Taylor, *bubuli*, *tambuli*, *tabili*, and *tambilihan* are among the names by which skinks are known to Filipinos, who, however, do not attempt to discriminate between the different species.

SNAKE-EYED SKINKS

The snake-eyed skinks differ from all others of the family in lacking movable eyelids. Members of this genus occur in Australia, Asia, Africa, and Europe. In the Pacific all the very differently colored kinds appear to be but insular races of a single species known as Bouton's snake-eyed skink after its discoverer, Louis Bouton, who found the first examples on Mauritius. Bearing in mind that the pattern varies from island to island, this exquisite little 4-inch lizard might be described as metallic greenish, olive, or bronze, with a widely separated pair of light greenish lines along the back, each of them more or less edged above and below by a black line; the flanks are often spotted or flecked with paler markings. The underparts from throat to tail-tip are greenish white.

Rocks or cliffs of coral rag occurring along the coast sometimes swarm with these wary and active lizards as they dart about wresting a living from the ocean. When too boisterous a wave deluges the rocks with spray, the little lizard dashes into a crevice seeking temporary shelter, then out again to seize some hapless sandhopper, sea

slater, or other form of marine life that may provide a meal. Though quick as a flash, snake-eyed skinks can be caught by a person equipped with patience, persistence, a soft duster, and a pair of forceps. An easier method is to shoot them with dust shot from a .22 shotgun, but great care should be taken to aim from a position where the tail is shielded by projecting rock. This is important, as these lizards discard their tails at the least excuse.

On islands where no rocks are available, this adaptable skink will adjust its life to local conditions and prosper among sandhills or similar situations near the shore. In damp earth near Kahului in the Hawaiian Islands, R. C. McGregor found scores of eggs. As many as seventy were stuck together in one clump, indicating that about thirty-five females had resorted to lay in this one spot. These eggs varied in size from nearly ½ inch to almost ¾ inch in length, by about ¼ inch to over ⅓ inch in diameter. Freshly laid eggs are pink but darken as the embryo develops. Within the egg the embryo lies coiled like a snake until ready to emerge. Then utilizing the temporary "egg-tooth" on the tip of its snout, it makes a slit or pair of convergent slits in the parchment-like envelope. Within twenty seconds of making its escape, the hatchling is running about, well able to take care of itself though only 1⅘ inches in total length.

BLIND-SKINKS

Each of the three remaining lizard families of the Pacific region has only one or two representatives there, though all have continental allies. The worm-like blind-skinks occur in Annam and Indochina, with a single species ranging from the Philippines to the Nicobars and eastward to New Guinea. In color these blind-skinks vary from pale brown to black both above and below; an occasional Philippine skink may have a blotch of silvery gray above, while it is usual for the anal region to be lighter. It is in that region that the males (fig. 33) differ so strikingly from the limbless females (fig. 32), for on either side of the anus is the vestige of a hind limb in the shape of a flipper-like scaly flap, the pair of them so closely pressed over the opening as to be

scarcely discernible. Never more than 9 inches long, these blind-skinks are frequently only two-thirds that length. Taylor usually found them under logs, but one was taken in sandy soil at the base of a tree. The shells of their eggs are said to be calcareous.

SCALE-FOOTS

In New Guinea and its adjacent islands may be found those strange-looking lizards called scale-foots, which have many relatives in Australia. The hind flaps (fig. 34) are so unlike limbs and so similar to the adjacent scales that I venture to think few persons will detect them. Adding to the general snake-like appearance of the yard-long tapering reptile are half-a-dozen stripes—some above and some below—along the entire length of the grayish body. From its appearance I should think that the scale-foot lives in long-grass country and darts away over the grassy tussocks when disturbed.

The two species occurring in New Guinea may be distinguished as follows:

Snout moderately long, its terminal scale quite twice as broad as it is high; 4 preanal pores ..... Burton's scale-foot (*Lialis burtonis*)

Snout very elongate, its terminal scale slightly broader than high; 6 to 8 preanal pores ..... Jicar's scale-foot (*Lialis jicari*)

"GLASS-SNAKES"

"Glass-snakes" are so called because of the brittleness of their tails which these limbless lizards discard at the slightest provocation. They have representatives in North and Central America, Africa, Europe, and Asia as well as the two species known from the Pacific. In Buttikofer's "glass-snake" of Borneo the pale brown upper surface is separated from the creamy white underside by a dark band along the flanks. Though the crown of its head is smooth, along the back and flanks are twelve conspicuous and continuous ridges resulting from each scale bearing a strong keel.

In Hart's "glass-snake" of Formosa and China there are from sixteen to eighteen of such ridges, while blue spots are arranged in cross rows on its pale yellow-brown back, at least in the male. One August day Clifford H. Pope found a female coiled about her five eggs in an irregular cavity several inches below the surface of a thinned-out bamboo grove. A second nest was found in a pile of rotting bamboo waste; the mother immediately fled when disturbed. Yet a third nest was discovered, this time beneath a large stone fully exposed to the sun, for it was lying out in an open field.

6

The Nonpoisonous Snakes

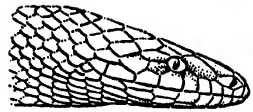
Of all reptiles the snakes are most worthy of our interest; for deprived of feet though they are, some kinds can outdistance a running man at least for a short stretch, without hands others can outclimb us, without fins outswim us, while still others bury themselves with astonishing agility unaided by sexton or shovel.

Instead of worshiping these mysteries of motion as did many of the ancients, too often modern man seeks only to batter the life out of every snake; then, viewing his handiwork, he justifies his action by quoting some foolish adage to the effect that "a dead snake is better than a live one." In reality fear of the unknown, allied with prejudice as a prime factor, are the causes of such conduct, for it has been proved beyond dispute that mankind has no "instinctive dread" of snakes. The dread acquired by a child is probably derived from observation of the attitude of its elders, coupled with stories of the death-dealing capabilities of some snakes.

The venomous species, however, constitute less than a fifth of the 2,500 kinds of snakes in the world, and even of this fifth very many cannot be considered dangerous to man. Of the 2,000 harmless kinds, many are distinctly beneficial from a human standpoint because they subsist on termites, earthworms, grubs, slugs, snails, centipedes, rodents, and even poisonous snakes. Others prey upon our friends the frogs, birds, or useful animals. To be able to recognize friend from foe is certainly worth taking some trouble.

PLATE V

35



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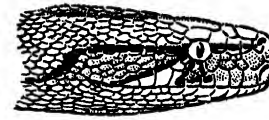

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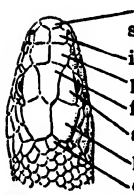

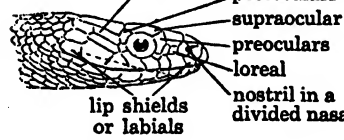

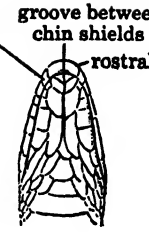

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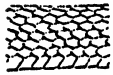

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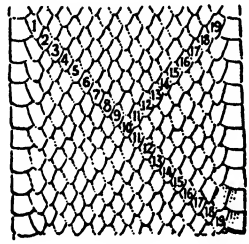

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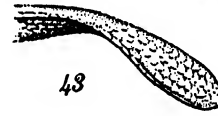

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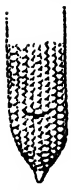

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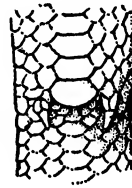

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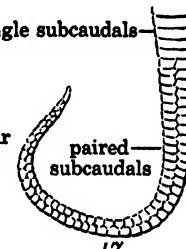


47

Key to the Snake Families of the Pacific [1]

1. Tail more or less round in section like the body (except in the case of a few species of freshwater or marine habits whose tails are slightly compressed, but which differ from sea-snakes in lacking poison fangs in front of upper jaw) 2

   Tail strongly compressed and paddle-shaped (fig. 43); habits aquatic, chiefly marine .. 11

2. Eye, when distinguishable, beneath a shield; body encircled by scales which are uniform

[1] Ranges extending beyond the Pacific islands not included.

PLATE V

Fig.

35. Head of a Brahminy blind-snake showing eye beneath shield.
36. Head of an iridescent snake showing eye beneath transparent scale.
37. Head of black-tailed python showing pits on anterior lip shields.
38. Head of a typical colubrine snake as viewed from above, side, and below.
39. Segment of a snake's body showing smooth scales.
40. Segment of a snake's body showing keeled scales.
41. Section of snake skin laid flat to show method of counting scales around middle of body to ascertain "midbody scale-rows."
42. Peculiar tail of death adder, round at its base but compressed toward its spine-bearing tip.
43. Tail of a sea-snake to show its compressed paddle-shaped character.
44. Tail of Brahminy blind-snake showing three scales bordering anus anteriorly.
45. Belly (showing slightly enlarged median scales = ventrals) and tail of red cylinder-snake showing two scales bordering anus.
46. Belly and base of tail of black-tailed python showing spurs.
47. End of tail of an elapid snake showing some subcaudals single or entire, others paired or divided.

in size; 3 or 4 scales immediately in front of anus (fig. 44); lower jaw without teeth; harmless; habits burrowing; range: Japan southwest to Sumatra east to Hawaiian Islands, etc. ..... blind-snakes (TYPHLOPIDÆ)

Eye distinct and well developed though sometimes small; both lower and upper jaw provided with teeth 3

3. Belly covered with scales similar to those on back; the series of scales along middle of belly not or but slightly larger than the others .. 4

Belly with a series of enlarged shields along the middle which are at least 3 times as broad as the scales bordering them 5

4. Anus bordered in front by 2 scales (fig. 45); tail very short, not prehensile; scales moderate, less than 25 around middle of body; eye with round or vertically subelliptic pupil; harmless; habits burrowing; range: Borneo southwest to Sumatra east to Batjan Island near New Guinea ..... cylinder-snakes (ANILIIDÆ)

Anus bordered in front by 6 scales; tail round or slightly compressed 8

5. Vestiges of hind limbs in the shape of spurs usually [1] visible on either side of the anus (fig. 46); tail usually prehensile; scales small, more than 30 around middle of body; eye with vertical pupil; habits arboreal or terrestrial; not poisonous; range: Philip-

[1] When absent, recognizable as a boa by having more than 30 midbody scale rows and no greatly enlarged poison fangs in front of upper jaw.

pines southwest to Sumatra east to Samoa and the Tongas ..... boas and pythons (BOIDÆ)

No vestiges of hind limbs; usually[1] less than 30 scales around middle of body 6

6. No enlarged poison fangs at front of upper jaw 7

One or more pairs of enlarged poison fangs on outside edge near front of upper jaw .. 10

7. Belly shields less than 3 times as broad as their bordering scales; tail short, not prehensile; scales glossy, in 15 rows around middle of body; eye with vertically elliptic pupil; harmless; habits burrowing; range: Philippines southwest to Sumatra east to Celebes ..... sunbeam snake (XENOPELTIDÆ)

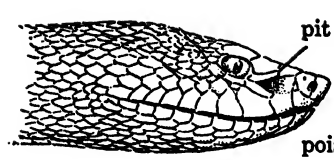
Belly shields more than 3 times as broad as their bordering scales 9

8. No enlarged poison fangs at front of upper jaw; scales granular, not overlapping; tail slightly compressed or round; not poisonous; habits freshwater and marine; range: Philippines southwest to Sumatra east to Torres Straits ..... granular snakes (COLUBRIDÆ part)

9. A groove between the chin shields (fig. 38) to allow of expansion (the majority of harmless and back-fanged snakes belong to this

[1] The three exceptions are a Sumatran water-snake with very short tail; Russell's viper of the Dutch East Indies, and the yellow-green pit-viper of the Luchus; both the latter have long poison fangs.

PLATE VI



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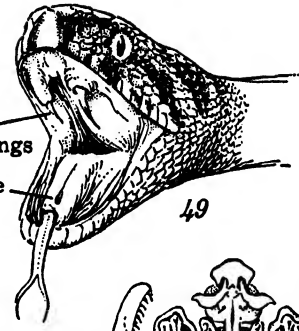

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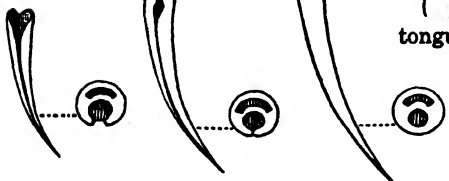

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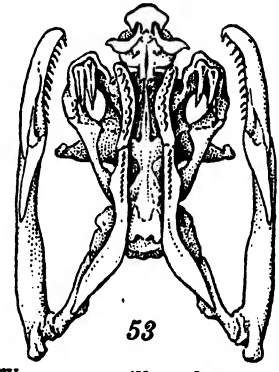
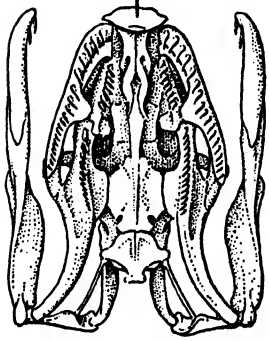


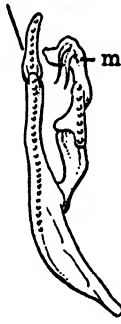
53

premaxillary bone



54

palatine bone



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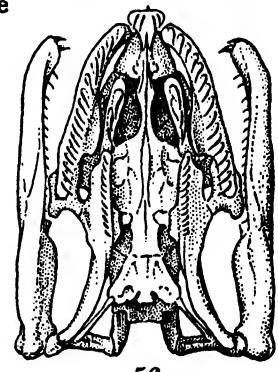
premaxillary bone



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57

world-wide family); range: Japan southwest to Sumatra east to the Solomons ..... colubrines, etc. (COLUBRIDÆ part)

No groove between the chin shields; 13 to 15 scales around middle of body (a group of slug-eating, chunky-headed, very slender tree-snakes); harmless; range: Borneo southwest to Sumatra east to Java ..... bluntheaded snakes (COLUBRIDÆ part)

10. Poison fangs grooved (fig. 51), immovable, not enclosed in a very large sheath; habits burrowing, terrestrial or arboreal; range: Formosa southwest to Sumatra east to Solomons ..... cobras, kraits, etc. (ELAPIDÆ)

Poison fangs perforated (fig. 52), movable, folded back when not in use, enclosed in a very large sheath of skin (fig. 49); habits burrowing, terrestrial or arboreal 12

PLATE VI

FIG.

48. Head of yellow-spotted pit-viper to show pit between eye and nostril.
49. Head of a Javan Russell's viper showing fangs, glottis, and harmless tongue.
50. Poison fang of sea-snake, and section showing open canal.
51. Poison fang of cobra, and section showing more or less closed canal.
52. Poison fang of viper, and section showing completely closed canal.
53. Skull of king cobra showing maxillary bone extending beyond the palatine (after Bogert).
54. Skull of Pacific boa to show absence of teeth on premaxilla.
55. Left side of a sea-snake's upper jaw viewed from below to show palatine bone extending beyond maxillary.
56. Skull of a python to show teeth on premaxillary bone.
57. Head and anterior third of a long-glanded snake's body with skin removed and poison gland dissected out to show its length (after Barbour).

11. Poison fangs grooved (fig. 50), immovable, rather short; habits aquatic, though chiefly marine, found in lake on Luzon, Philippines, and Rennell Island, Solomons; otherwise range: Pacific Ocean from Japan southward and east to Panama, etc. ..... sea-snakes (HYDROPHIIDÆ)

12. No deep pit between nostril and eye (fig. 49); range: Islands of Sakhalin, Sunda, and Java ..... true vipers (VIPERIDÆ)

A deep pit between nostril and eye (fig. 48); range: Philippines southwest to Sumatra east to Celèbes and Sangir Island ..... pit-vipers (CROTALIDÆ)

BLIND–SNAKES

On the islands of the Pacific are nearly fifty different kinds of burrowing blind-snakes. No less than twenty-five of them have been described as new since World War I, and without doubt many more remain to be discovered. Thus from the student's point of view these worm-like reptiles are among the most interesting of all Pacific snakes, though as pets one must confess they are disappointing. This is because of their secretive ways, which are also responsible for many species having remained undiscovered for so long.

Blind-snakes are more likely to be confused with limbless lizards than with any other type of Pacific snake; in fact, they are so distinctive that after one blind-snake has been caught and examined, any member of the family will be recognized. The difficulty lies in finding one, for they remain below ground until flooded out by a heavy shower, after which an occasional blind-snake may be found wriggling clumsily on the surface. Of course, a snake or two may be uncovered during the clearing of a landing field or camp-site. Grab it quickly, for it may be the last you will see though you occupy that camp for months.

For anyone who wishes to hunt blind-snakes, a hoe is almost indispensable. It is possible to expose a snake by turning a decaying log, but more often it is necessary to dig down a few inches in the spot where the log has been lying. The galleries of old termite ("white ant") hills may yield a harvest of these snakes, for the same reason that one of the most promising places to search for them is beneath the rotting thatch of a collapsed hut. Termites abound in such places, and it is termites that figure as the principal item on a blind-snake's bill of fare. In the Philippines, Taylor found blind-snakes in what seemed to be a most unlikely situation. He took a dozen snakes of three different kinds from the root-masses of an aerial fern (*Asplenium nidus*) when the ferns came crashing to earth with the felling of the giant forest trees upon which they were growing.

Though commonly spoken of as "degenerate," in reality these blind-snakes are wonderfully fitted for their role in life. Their cylindrical shape and highly polished scales are calculated to offer a minimum of resistance as they are being forced through the soil. To aid in this, the very short tail often ends in a spine which provides a purchase. Upon picking up a squirming blind-snake, you will probably feel a prick from this spine as the struggling reptile presses its tail against your hand. The prick does not amount to anything, yet some native peoples are terrified of it, declaring that the snake has a sting at one end and will bite you with the other. Both beliefs are faulty. The blind-snake's tiny mouth, with no teeth in the lower jaw and only minute ones in the upper, is quite incapable of biting even a moderately large surface. Sometimes the mouth, which is a tiny slit on the lower part of the head, rather reminds one of the mouth of a shark, and is so like the anal opening at the other end of the snake that unobservant aborigines often call one of these reptiles "snake with two mouths" or even "two-headed snake," a title they share with the cylinder-snakes. There is some excuse for this, as the tail is so stumpy that in certain blind-snakes it is only a little longer than broad. The snout also may be bluntly rounded, though some blind-snakes have a rather sharp snout which projects strongly and seems better adapted to forcing a passage through sandy soil.

In addition to termites, blind-snakes consume both ants and their pupæ, as well as the eggs and grubs of beetles or other burrowing insects, the young of centipedes and earthworms, and at times even the eggs of other snakes. Their own eggs, numbering from two to seven in the case of the Brahminy blind-snake, have been compared to grains of cooked rice, for they are only slightly over ½ inch in length and about ⅛ inch in diameter.

BRAHMINY BLIND-SNAKE

This Brahminy blind-snake, called *amagaku* or *meku habu* in Japan, ranges all the way from that country southwest to Sumatra and east to Honolulu and Mexico. It has been taken on Guam and in the Marianas and has a still wider distribution outside the Pacific. Obviously so extensive and spotty a distribution must be attributed in part to human agency, for the snakes have been carried in ballast or in the soil among the roots of tropical plants transported by horticulturists. The genus *Typhlops*, to which belong all Pacific species of blind-snakes, is found in the warmer regions of the six continents.

The Brahminy species is black or pearly gray above and somewhat paler below; it is likely to have the anal region and tail-tip creamy white, and more rarely the head also. It is under 7 inches in length and about ⅕ inch in diameter, and is probably the commonest member of the group to be found in the Pacific.

CYLINDER-SNAKES

Of the nine species of cylinder or pipe-snakes recorded from the East Indies, the best known is the red-tailed cylinder. The Malays know it as *ular kapala dua*, or two-headed snake, in allusion to its behavior when molested. At such times this perfectly harmless reptile rears and flattens its tail, often poising it like a head about to strike and jerking it about while the real head is tucked beneath a coil. This conduct brings into sudden prominence the crimson underside of the tail, which is in striking contrast to the general black or brown coloring of the upper surface, sometimes uniform but more often with numerous light crossbars. Apart from the tail, the underside is white,

barred or blotched with black. In wriggling away, the reptile applies its real head to the ground while continuing to hold the tail aloft, giving the impression of a snake retiring backward with its "head" ready for a rearguard action.

This curious habit is shared by the Celebes red-tailed cylinder and possibly by all of the family. Stranger still, it is also practiced by a totally unrelated *poisonous* species found in the same islands, a fact which it is as well to remember. Certainly some Malays fail to differentiate between the poisonous and harmless species. In an effort to convince one native of the harmlessness of a red-tailed cylinder, Shelford pried open the snake's mouth and forced it to bite him. Then, turning to the Malay, he pointed out that the tiny teeth were too feeble even to puncture the skin. Quite unimpressed, the man merely remarked that white men were certainly fortunate to be unaffected by even poisonous snakes!

Another power possessed by red-tailed cylinder-snakes is to vary their outlines from cylindrical to an almost ribbon-like flatness, an ability which enables them to squeeze through narrow clefts or, Houdini-like, escape from captivity through seemingly impossible cracks. They feed upon small blind-snakes, eels, earthworms, and any grubs they may encounter in their subterranean wanderings. Their young are born alive. Weber's cylinder-snake of Sumatra differs from all the rest in having the scales beneath the mouth irregularly arranged so that there is no longitudinal groove to permit of expansion during the swallowing of large prey.

BOAS AND PYTHONS

From the relatively small cylinder-snakes averaging a foot or two in length, to the boas and pythons, largest of the serpent tribe, may seem to be an unjustifiably long stride. However, as members of both families agree in having a far more generalized skeletal structure than many other snakes, they are more primitive than any of the others, among which the death-dealing cobras and vipers must be considered the most highly specialized.

The boa family is divided into two subfamilies, that of the boas

(BOINÆ) and that of the pythons (PYTHONINÆ). It might be pointed out at once that none of the five boas found in the Pacific exceeds a yard in length by more than a few inches; most of them are much smaller. Any really large member of the family encountered, therefore, is a python and not a boa.

PACIFIC BOAS

The little Pacific boas have rather angular snouts; their heads are covered above with small scales, their body scales are strongly keeled, and the short but prehensile tail tapers off very abruptly to a point. Even within the limits of a single species their coloration is surprisingly variable, but one might describe all five Pacific forms as yellow-brown, olive-brown, red-brown, or dark brown, with or without a series of even darker spots along the back; these spots often unite so as to form a chain or zigzag marking. Though boas are abundant on many of the islands, little seems to have been recorded of their habits. C. H. Pope states of the rough Pacific boa that it is said to leap forward, a statement requiring confirmation. One of this species was taken swimming in the sea at Matterer Bay, New Guinea, which in part may well explain their wide distribution in the islands east of New Guinea. From their relatives the pythons they may be distinguished as follows.

KEY TO THE GENERA OF BOAS AND PYTHONS OF THE PACIFIC[1]

1. No (supraorbital) bone above eye;[2] no teeth on premaxillary bone in very front of upper jaw (fig. 54); range: Moluccas east through New Guinea and Polynesia to the Society Islands ..... Pacific boas (*Enygrus*)

   A (supraorbital) bone above eye;[2] subfamily PYTHONINÆ 2

[1] Ranges extending to African, Asiatic, or Australian mainlands not included.

[2] The presence or otherwise of a supraorbital bone can usually be ascertained by slight pressure on that region. If no bone is present, it will be flexible; if present, then rigid.

2. No teeth on premaxillary bone in very front of upper jaw (fig. 54); range: Aru and Schouten Islands east through New Guinea to the Solomons — green python (*Chondropython*)

   Teeth on premaxillary bone in very front of upper jaw (fig. 56) 3

3. Snout scale and adjacent ones bordering upper lip with deep pits (fig. 37); tail prehensile 4

   Snout scale and adjacent ones bordering upper lip without, or with only shallow, pits; tail not or but slightly prehensile 5

4. Head between eyes covered with scales or small irregular shields; first 2 or 3 scales bordering upper lip pitted; range: New Guinea and Union Island ..... diamond python (*Morelia*)

   Head between eyes covered with large symmetrical shields; first 2 or 4 scales bordering upper lip pitted; range: Formosa southwest to Sumatra east to Timor Laut ..... typical pythons (*Python*)

5. Nostrils opening upwards and outwards in a semi-divided nasal scale; range: southern Philippines south to Timor east through New Guinea to Torres Straits and the Bismarck Archipelago ..... rock-pythons (*Liasis*)

   Nostril opening directed sidewise between 2 nasal scales; range: New Guinea and Bismarck Archipelago ..... ringed python (*Bothrochilus*) [3]

[3] This name, as pointed out to me by Dr. O. G. Stull Davis, has precedence over the better-known names *Nardoana* and *Nardoa*.

GREEN PYTHON

The beautiful green python or *yamomong*, as it is called in some parts of New Guinea, is distinctive enough in its rich green phase, even though it may or may not have yellow spots along the back. It is not always so colored, however, for the young may be reddish brown with a fine vertebral line from nape to tail flanked by triangular, brown-edged, yellow blotches, with a second series along the sides. This tree-dwelling species attains a length of nearly 5 feet.

DIAMOND PYTHON

Also reaching New Guinea is the better-known Australian diamond python, which owes its name to the diamond-shaped, black-edged, yellow patches on its usually dark olive skin. Each scale of the back has a yellow spot but the belly is uniformly yellow. Though rarely exceeding a length of 9 feet, the diamond python may grow to at least 14 feet, according to R. L. Ditmars.

These pythons form no exception to the general rule that normally all snakes feed on live animals. The prey is seized by a sudden forward lunge and then, in the case of pythons, whipped back among the coils where it is soon suffocated by relentless pressure. When all movements of the prospective meal have ceased, the snake runs its snout over the corpse as the delicate, flickering, forked tongue transfers odor-bearing particles to appropriate receptacles in the roof of the mouth. When by this means the python has located the head of its prey, it takes the muzzle in its jaws and commences to draw the food into its mouth in a manner that is truly astonishing.

In addition to the small patch of teeth in the front of the upper jaw mentioned in the preceding key, pythons have six separate rows of teeth all of which are brought into play when feeding. Two of the rows are on the reptile's palate while the right and left rows of both upper and lower jaws are united only by a very elastic ligament which permits of wide separation. These six rows are capable of independent action, so that first those on one side, then those on

the other are thrust forward, hooked into the prey, then drawn backwards. The whole process somewhat resembles the manner in which a man hauls in a rope. As the food is drawn in, the numerous small bones of which the snake's skull is composed spread apart; the head often loses all shape until the bulkiest portion passes on down to cause a bulge in the "neck" and then the stomach.

During the swallowing of particularly bulky food, breathing becomes difficult; in fact, it seems possible that the snake might choke if it were not for the walls of the windpipe being strengthened by rings of cartilage. In exceptionally labored feeding the epiglottis, or opening of the windpipe lying on the floor of the mouth (fig. 49), is sometimes pushed forward beneath the prey and between the right and left lower jaw bones until it protrudes beyond the mouth. After a few deep breaths have been taken, it may slowly recede to its normal position.

The passage down the throat is rendered easier by a copious flow of saliva, which accompanies the swallowing process. This is why, on cutting open a snake, one finds the prey coated with slime. The idea that the slime was applied by the fine points of the slender tongue is just as ridiculous as the old-fashioned notion that the soft tongue was a "sting" capable of puncturing the human skin. Actually the tongue is so delicate and valuable to its owner that it is withdrawn into a sheath in the floor of the mouth as soon as the snake starts to swallow.

Because of their strongly recurved teeth, diamond pythons, like others of their kind, sometimes become involved in accidents, at least when in captivity. One diamond python engaged in swallowing a rabbit in the Adelaide Zoological Gardens, managed to get its teeth hooked into a corner of its sleeping blanket, which then followed the rodent through the 12-foot python. Another of the pythons started to swallow a rabbit just as an African python, which shared the cage, began at the other end of the mammal. The intervening space rapidly narrowed until the snouts of the contending diners met. A moment's hesitation, then the jaws of the larger snake gaped widely and his cousin's head disappeared, followed slowly by the protesting body.

After encompassing this gargantuan meal the victor was decidedly unwell for several weeks, but in due course his gastric juices accomplished their task and he fully recovered his former health and appetite. The longevity record for this species in captivity is held by a diamond python in the Dublin Zoological Gardens which lived for thirteen years and five months.

RETICULATED PYTHON

A diamond python's achievements in swallowing are feeble when compared with those of its huge cousin, the reticulated python of Malaya. This beautiful reptile ranges from the islands immediately west of New Guinea to the Philippines and on the mainland from southern China to Burma. Reticulated pythons are known to reach a length of 32 feet, and therefore this species has the distinction of being the longest snake in the world. Few individuals attain the maximum dimensions and a 20-footer is considered quite a large specimen.

The name "reticulated" is derived from the chief characteristic of the complex and highly variable pattern which adorns its iridescent skin. From snout through eye to neck runs a fine black line; a similar line extends backwards from the snout across the crown of the otherwise largely brown head. The deep blacks, browns, and yellows of the intricate body pattern are too bewildering to describe, but if one bears in mind that it is comprised of zigzag or X-shaped dark markings, there should be little difficulty in recognizing an adult reticulated python. The young often exhibit black-edged light spots arranged in three longitudinal rows along the back.

Large reticulated pythons are greatly feared by native communities, and not without reason, for the reptile's man-killing propensities have been established beyond doubt, though authenticated instances appear rare. One concerns a Burman named Maung Chit Khine, who set out with four companions on a hunting excursion. After leaving Thaton, the party were overtaken by a thunderstorm and Khine sought shelter beneath a big tree. He failed to rejoin his

friends, and when they started to search for him, they discovered his slippers and nearby a gorged python between 20 and 30 feet long, according to their story. They killed the snake and on opening it found the body of their late companion inside; he had been swallowed feet first!

The late Robert Shelford, once curator of the Sarawak Museum, relates that a Dyak was seized by the leg as he was passing a tree against whose trunk hung a python. Fortunately for the man, he was being followed by a companion who struck off the snake's head. The scars left by the bite remained on the man's leg for many years. Shelford suggests caution in accepting every tale of deaths from pythons, plausible though they may seem. He cites two instances where subsequent examination of the corpse revealed that death was due to the coils, not of a snake, but of rattan which had been wound about the victim by murderers, who had not realized that a python's coils leave no weals.

Among reliable stories Shelford quotes one involving a boy of about ten or twelve years of age. The lad was sleeping on the ground beside his father in their hut at Judan, six miles from Muka, Sarawak. In the middle of the night the child cried out. The father, awaking, passed his hand over his son but finding nothing amiss concluded that the boy had been dreaming; so, turning over, he fell asleep. Once again he was aroused, this time by the child exclaiming that a crocodile had seized him. Now thoroughly alarmed, the father felt again and found that a snake had taken the boy by the head. The father managed to pry open the reptile's jaws, but while doing so was himself enveloped in its coils. In response to their shouts for help, neighbors arrived and succeeded in killing the snake, which proved to be about 15 feet long. The youngster's head was encircled with wounds caused by the python's teeth.

A fight with four reticulated pythons ranging from 20 to 26 feet in length has been described by Carl Hagenbeck. The affair started when his son Heinrich entered their cage at the Stellingen Zoo and all four snakes attacked him simultaneously. Fortunately, help was forthcoming but the subsequent struggle was no easy one, though

it ended successfully with the four reptiles being safely packed and shipped to the St. Louis Exhibition of 1904.

In a wild state, the natural food of these big snakes is pigs and deer, or dogs and goats when near villages. One might suppose that the horns of deer and goats would cause some trouble, but actually when they happen to penetrate the stomach wall and skin they fall off as soon as the skull has been digested. The wounds they have caused appear to heal without complications.

Hagenbeck records a 25-foot python as swallowing a dead, 31-pound de-horned goat; a few hours later the same reptile took a 43-pound buck, whose ingestion occupied half-an-hour. A week later another goat, this one weighing 52 pounds, was swallowed by the same snake. This last meal took two hours to assimilate and was evidently overmuch, for shortly afterward the python threw it up again. However, another python swallowed an 84-pound goat!

Statements to the effect that these larger snakes feed only twice a year, or once a month when young, appear to have been based on insufficient data. At the London Zoological Gardens a 22-foot reticulated python ate thirty times during the year, its food consisting of sixteen kids and seventeen ducks. During the same period, a 14-foot python took thirty-one ducks and eight pigeons in the course of thirty-two meals. It was noted that the snakes fed twice as often in summer as they did in winter.

Of course, a snake may fast deliberately; in fact, it usually does so when first caught. More rarely an individual will exhibit a marked preference for some particular food and starve rather than accept any other. This was the case with a reticulated python that lived for many years in the Jardin des Plantes in Paris. Months went by, and though guinea pigs, rabbits, kids, and various birds were given, all were rejected. Then one day a goose was put into the cage and was immediately seized by the python. With the long fast broken, it was thought that the snake would now accept the usual type of fare taken by pythons. Not a bit of it; to the end of its life that python refused to touch anything but geese!

In the matter of reproduction, pythons are interesting. As opposed

to boas which give birth to live young, they not only lay eggs, usually in the hollow trunk of a fallen forest giant, but they guard and actually incubate them. For a cold-blooded reptile whose temperature supposedly depends on that of the surrounding atmosphere, this is indeed surprising. At various times, however, sundry investigators have slipped thermometers between the coils of brooding pythons and noted that the female was from one to twenty degrees warmer than her mate and from ten to thirty degrees warmer than the cage they occupied.

Pythons' eggs are quite sizable, measuring about 3½ by 2½ inches or more, and covered with the permeable parchment-like shell characteristic of snakes' eggs. One reticulated python laid 103 eggs, of which 88 hatched. Hatchlings of this species measure about 20 inches in length, but some in the Jardin des Plantes grew to 80 inches, and one even to 92 during the first twenty months after hatching. Much depends on correct temperature and the amount of individual care accorded to each snake, but generally speaking, a 10-foot python is about three or four years old. Growth slows down with advancing years, however, for we learn that a python which measured 11 feet on its arrival at the London Zoo grew to be 21 feet long in the course of ten years. Another took fourteen years in which to grow from 19 to 24 feet. On this basis we can roughly estimate growth as proceeding at the rate of a foot per year in the period between 10 and 20 feet, but at only about half that rate subsequently. We can dismiss suggestions that a 20-footer is twenty years old and a 30-footer about seventy, as being highly speculative and almost certainly wrong. After all, no reticulated python has lived in captivity for more than twenty-two years, and no snake of any kind for more than twenty-three. A 28-foot reticulated python weighed 250 pounds. No one can say what their span of life is in a wild state, but for pythons it is unlikely to be much in excess of that in zoos, for even big pythons have their enemies.

Among these, man must be considered the chief. Not only do many native peoples relish the white flesh of a python, but they hunt the reptile for the sake of its hide, which commands a high price. Even

such unlikely creatures as wild pigs may at times tackle a big python. This is shown in the following observation by that trustworthy naturalist Ernest Hose, as related by Shelford,[1] who writes:

"Hearing one day in the jungle, close to his house at Santubong, a tremendous noise of wild pigs grunting, snorting, and squealing, he ran out to see what was the reason of it, and presently came on a large python that had seized a young pig and was endeavouring to crush it. The snake was surrounded by a number of full-grown swine, which were goring it with their tusks and trampling on it; so resolute was their attack that the python was obliged to relinquish its hold of the loudly protesting young pig, when the herd, catching sight of Mr. Hose, hastily made off, the young one, apparently little the worse for its adventure, trotting away with its companions. Mr. Hose examined the snake, and found it to be so slashed and mangled that it was unable to crawl away from the scene of battle." It might be added that, but for the interruption, the swine would probably have eaten the snake, judging by the way they devour smaller serpents.

TIMOR PYTHON

In addition to the reticulated python, four other members of the genus are to be found in the East Indies region. The Timor python, rare in museums, is known from Flores and Timor Islands. It agrees with the reticulated species in having the first four scales of the upper lip pitted and in the fine black line extending from snout to crown. It is said to differ in having only 60 (instead of 69 to 79) rows of scales around the body, and only 288 (instead of 297 to 330) broad scales on the belly. The largest example known is about 10 feet in length.

BREITENSTEIN'S AND SCHLEGEL'S PYTHONS

The remaining three pythons have, in addition to the snout shield of course, only the first pair of shields on either side of the upper lip

[1] *A Naturalist in Borneo*, 1917, p. 43 (E. P. Dutton & Company).

pitted. Breitenstein's and Schlegel's pythons, from Borneo and Sumatra respectively, are but island representatives of a Malayan form. Almost covering the side of the head, or at least from the eye to the neck, is a broad black band interrupted by a white streak descending from the eye to the corner of the mouth. Though reaching a length of 10 feet, these two snakes are usually much smaller. They subsist largely on the rats which they find in the swampy districts where these pythons live.

BLACK-TAILED PYTHON

The black-tailed python of Celebes, Sumbawa, Java, and Hainan extends its mainland range through southern China to Burma, but it is replaced in India and Ceylon by a paler form commonly called the Indian python. Dark brown above, the black-tailed python has a series of black-and-white-edged, reddish brown, squarish blotches along the back and some less distinct ones on the sides. However, the character which serves to separate it from all the other pythons previously mentioned is a javelin-shaped marking on the top of the head. An additional difference distinguishing it from the Breitenstein's and Schlegel's pythons is the sixty to seventy-two pairs of shields beneath its black tail, just double the number found in the shorter-tailed reptiles from Borneo and Sumatra. There is some doubt as to the length to which a black-tailed python may grow. Ditmars measured one of almost 20 feet, but statements that it reaches 30 feet are very questionable and require confirmation.

ROCK-PYTHONS

Recognition of the eight forms of rock-python inhabiting New Guinea and neighboring islands may not prove easy in the field, as several of them have pitted lip shields, and the decision as to whether a tail is prehensile or not will at times be difficult. Only the amethystine rock-python reaches a length of 21 feet; the others do not exceed 8 feet. Basically, their coloration ranges from olive-brown to pur-

plish brown, either uniform or with a tendency to dark crossbars on the back and spots along the sides. Rock-pythons prey on small animals and birds. Apparently they are less particular about incubating their twenty to thirty eggs than are the true pythons.

RINGED PYTHON

Even smaller is the ringed python of New Guinea and the Bismarcks, for the largest examples known measure less than 5 feet. Young ones are ringed with black and orange, but the adults are brown with black rings or even uniformly blackish brown. Like most pythons, the ringed python hunts at night and feeds on rats and mice.

SUNBEAM SNAKE

Somewhat similar in habits to the cylinder-snakes is the sunbeam or iridescent earth-snake, a species so highly iridescent that brilliant lights of electric-blue, emerald-green, blood-red, purple, or copper flash from its scintillating scales as it wriggles along. Actually, the adult reptile is uniformly blue-black or rich brown above, except when the light edges of the scales produce a striped effect. The young have whitish or yellowish heads or collars, but these light areas darken with growth so that no trace of them remains long before the full length of 4 feet is attained.

It is curious that so beautiful a reptile should live so exclusively underground or concealed beneath boulders and logs, for, barring an accident, it comes to the surface only at night when in pursuit of its prey—mice, rats, frogs, other snakes, and occasionally even a bird. It is of uncertain temperament, for some writers regard it as vicious and others speak of captives that never attempted to bite. Flower tells us that an adult, when molested, twisted itself into an irregular pile of tight coils with the tail projecting from one side clear of the ground, its tip vibrating at great speed.

This behavior is reminiscent of that indulged in by the ball python and various burrowing boas, a group from which the sunbeam snake

is believed to have sprung though it differs from them in lacking all trace of vestigial hind limbs or spurs. On the other hand, it looks extraordinarily like some of the harmless colubrines, more especially like certain depressed-headed species such as the wolf snake. Turn it over, however, and you will see that the belly shields of the sunbeam snake, though broad, are certainly not more than three times as broad as the neighboring scales, so it is not a colubrid. Such a trifling difference alone would not justify the sunbeam snake in being accorded the distinction of family rank, for it is the only member of the suborder Serpentes which has family status for itself alone. This distinction is necessary on account of important structural characters, such as that of the nasal bone being in contact with the prefrontal bone in sunbeam snakes and separated in the colubrids.

COLUBRID SNAKES

To do full justice to the COLUBRIDÆ will be impossible, for within its ranks are the great majority of Pacific snakes—well over 300 of them, of which nearly 200 have been described from the islands during the present century. While some of the species are aquatic and others arboreal or burrowing, most of its members are terrestrial, and it is among them that we find those active forms that are best equipped for speed. It is for this purpose that the belly shields are so broad, for they play an important part in the locomotion of most snakes.

Their role is much the same as that of the paddles of a paddle-wheel steamer, but instead of being affixed to a wheel the belly shields are attached to the elongated underside of a snake, and instead of pushing against water their free edges strike against irregularities of the ground. The free edges of the belly shields, so neatly overlapping when the reptile is at rest, are raised in continuous rhythmical succession by muscles attached to the tips of the ribs. The ribs themselves articulate in pairs with their respective vertebra, of which there may be 100 or more, according to the species. In one sense the snake might be said to travel on its ribs, but so beautifully coordinated is this

remarkable piece of animal mechanism that an active snake appears to flow over the ground in sinuous curves which take advantage of any projection encountered.

GRANULAR AND WART SNAKES

Of course, a wholly aquatic snake would have no need of broad belly shields. Accordingly, it is not surprising to find the bodies of two fish-eating members of the Colubridæ encircled by rough granular scales. When taken from the water, these snakes cannot glide, but achieve laborious progress by heaving themselves clumsily forward. On land, with their skins hanging loosely about them, I can think of no uglier snakes than these rather shapeless reptiles; even their beady eyes contribute to the evil appearance, which is apparently matched by as ugly a disposition. Of the two, the granular snake is the better looking, for its muddy brown color is relieved on the flanks by numerous light bars, which are quite white in the young. Similarly the young of the wart snake, or elephant trunk snake as it is sometimes called, has on its yellowish sides irregular brown blotches that soon run together and eventually merge with the brown of the back. These two water-snakes haunt river mouths and enter the sea quite freely. They may be distinguished by their prehensile tails, which in granular snakes are slightly compressed, but roundish in wart snakes. Neither species much exceeds 4 feet in length, but their uncouth bodies have a greater diameter than is usual with snakes of that length. This is particularly so with gravid females, for both kinds are viviparous; one wart snake has been known to give birth to twenty-seven young.

Besides these entirely aquatic snakes, there are nearly forty semi-aquatic species belonging to the same genus (*Natrix*) as the water-snakes of North America and the grass or ringed snake of Europe, a genus which has other representatives in Asia and Australia. That this is a fairly ancient group seems indicated by its world-wide distribution, but salt water may not be a serious barrier to their dispersal for a grass snake has been found swimming in the English Channel far from land. Good swimmers though they are, it would be more cor-

rect to regard these water-snakes as denizens of marshlands, swamps, and river-banks, rather than of the water itself.

CHECKERED KEELBACK

Frogs and fish form the staple food of water-snakes, and this diet has gained for one of their number the scientific name of *piscator* or "fisher." In English it is generally known as the checkered keelback, in allusion to its color pattern and keeled scales; such keeling is common to all members of the genus as now understood. As for coloring, it may be olive-green to olive-brown above, the checkered pattern being formed by a series of squarish black blotches, but considerable variation is displayed. A 4-foot checkered keelback is a well-proportioned snake; its tail comprises but a quarter of its total length. Apart from an extensive mainland distribution, the species ranges from Formosa southwest to Sumatra and east to Celebes.

When menaced, this very active snake will sometimes leap clear of the ground in its efforts to escape from threatened danger. Usually such statements about snakes result from the none-too-careful observations of agitated onlookers, but in this instance may be accepted on the reliable authority of the late Colonel Frank Wall. He considered the checkered keelback, though nonpoisonous, to be one of the most vicious of snakes, biting with such suddenness and determination that its jaws had to be pried open before it could be induced to relinquish its hold.

GREATER RAT-SNAKE

In point of size and speed, the greater rat-snake of Java, Sumatra, and the mainland probably outstrips all the other harmless colubrids of the Pacific, for it reaches a length slightly in excess of 10 feet. This snake looks like an American racer except for the ridged or keeled appearance, due to the prominence of the underlying backbone, which is conspicuous even in well-nourished specimens. Its general color is yellowish to olive-brown; the lip shields are edged with

black and the hinder part of the body is frequently banded with black.

The bright eyes and quick movements of the head indicate a nervous temperament, and such it has, for it seeks to escape with the utmost speed when disturbed. However, if brought to bay it will defend itself fiercely and with courage, flattening its neck cobra-fashion and striking savagely. Wall relates how Father Dreckman chased a rat-snake, intercepted its retreat, and placed his foot over the hole for which the reptile was making. Without hesitation the nearly 8-foot snake coiled and launched itself at the priest's face. The man managed to evade the strike by moving his head, but the snake bit his shoulder and lacerated the skin through the clothes he was wearing.

Though a fondness for rodents leads the rat-snake to visit human dwellings, its name by no means sums up the scope of its diet. One rat-snake in whose stomach were half-a-dozen bats, was killed in a hollow tree that harbored a colony of these animals. The skill in climbing displayed by rat-snakes makes it possible for them to capture small squirrels, birds, and lizards, besides other snakes. Toads and frogs offer so little resistance to being eaten that they are frequently gulped down alive, and at times may be heard croaking in the snake's stomach. On several occasions Wall released the engulfed victims, which, after a few minutes, recovered sufficiently to hop away. Female rat-snakes are said to coil about their eggs, of which from ten to fourteen are laid at a time. These eggs vary considerably in size, so that they may be anywhere from 1⅝ to 2⅜ inches in length by 1 to 1¼ inches in breadth.

STRIPE-TAILED RACER

Another egg-laying constrictor of similar dietic tastes is known as the stripe-tailed racer, the *ular bulan* of the Malays. This 5-foot species may be considered as fairly typical of a dozen large reptiles (*Elaphe*) occurring in the western Pacific from Japan southwards throughout the Dutch East Indies. In the United States they are represented by several well-known species such as the chicken and

corn snakes; many kinds occur in Asia and a few in southern Europe or northern Africa.

The black stripes to which this snake owes its English name are four in number, two on the upper and two on the lower surface of the tail, the four intermediate lines being yellowish or white. The head and body present a very different appearance, as they are ashy gray or olive; a broad black bar extends for a short distance behind the eye, and the body is variegated with irregular black markings somewhat resembling the letter H. Posteriorly these figures are less distinct, for there they are broken by a broad light band extending along the center of the back.

In Malaya stripe-tailed racers have become cave-dwellers. The reason is to be found in the bats upon which they subsist and which furnish so abundant a supply of food that stripe-tailed snakes are said to be much more numerous in the caves than elsewhere. Some of the reptiles were found in the far interior of the caves where daylight never penetrated, others in the darkest recesses. When cornered or disturbed, they made a noise that has been described as between a mew and a squeal, and not in the least like a hiss. Apart from caves, these stripe-tailed racers often take up residence in human dwellings, frequently in the roof, for they are active climbers. There, like their close relative the *ular tikus*, they play a beneficial role in keeping down the rats and mice. The prey is seized with a lightning-like stroke and choked by a few coils of the snake's powerful body. The stripe-tailed species lays about a dozen eggs, which measure approximately 1 by 1½ inches.

DWARF-SNAKES

In striking contrast to such big snakes are the numerous dwarf-snakes of the genus *Calamaria*. About fifty different kinds of these short-tailed burrowing reptiles are found in the Philippines and Dutch East Indies, each of them with only thirteen rows of scales around the middle of the body, which in diameter is much the same as an ordinary pencil. Few of the dwarf-snakes exceed a foot in length and all

appear to be of a gentle disposition. Actually a dwarf-snake's mouth is so small that it is doubtful if it could gape widely enough to bite a human hand. Nevertheless, the Malays call one species *ular lima kendiri.* Now a "*kendiri*" is a coin worth three Malay cents or considerably less than United States two cents, so that the name amounts to "15-cents snake" and is meant to imply that the bite of one can be cured with 15 cents' worth of medicine. As already indicated, the bite is harmless, if one is possible. So small is the mouth and so restricted the dilatability of the throat that a dwarf-snake's diet is largely confined to worms and insects. Some species display a form of defense in having the tail colored like the head and carrying it upraised in the manner already described for the cylinder-snakes (p. 113), so the false head of the retreating snake appears poised and ready to strike.

REAR-FANGED SNAKES

Not all members of the Colubridæ family are nonpoisonous, for quite a number—nearly fifty kinds on Pacific islands—have grooved teeth at the *rear* of the upper jaw just below, or below and behind, the eye. Down the groove flows venom or venomous saliva, but the mechanism of its supply is not perfected as in the really dangerous *front*-fanged snakes. Still the arrangement is of advantage to its owners, enabling them to administer a quietus or even to kill, struggling prey as it is being swallowed. Snakes furnished with grooved teeth of this type are inclined to chew at their prey while swallowing it so as to insure inoculation of the venom. These back-fanged snakes are usually not considered dangerous to man, for the venom-conducting teeth are situated too far back in the jaw to come into play when biting. While this is the case with the majority of back-fanged snakes, as they are only of moderate size, a few larger species are potentially dangerous, for their gape may be sufficiently wide for an effective bite. A South African member of the group is reported to have seriously poisoned a man who was handling it.

Pacific members of the group have long been considered as forming

two subfamilies of the Colubridæ, the one aquatic, the other very largely arboreal. In recent years this arrangement has been discredited to some extent by the discovery that in certain genera, and in at least one African *species*, the rear fangs may or may not be grooved. For the present it is convenient to regard these rear-fanged snakes as a definable group.

The dozen or more aquatic members of this group range from Sumatra eastwards to New Guinea. They may be recognized by their valvular nostrils, placed on the upper surface of the snout, as opposed to the non-valvular and laterally placed nostrils of their arboreal or terrestrial relatives. Snakes of both groups have broadish shields along their undersides.

DOG-FACED WATER-SNAKE

Probably the commonest of the aquatic forms is the dog-faced water-snake, a light or bluish gray reptile with a dark streak extending from the eye backwards along the neck while its back carries numerous dark, though ill-defined, crossbars. The buff-colored belly is mottled with deep greenish black.

It is a powerful swimmer, frequenting the brackish waters of estuaries where it sometimes anchors itself by the tail to a submerged branch or underwater stake. There it will remain, allowing the current to swing it to and fro while on the lookout for the fish or eels upon which it preys. Occasionally the snake itself is hooked by a fisherman. Dog-faced water-snakes like to climb among the branches of mangroves or waterside bushes, dropping off into the stream when disturbed after the manner of water-snakes the world over. Out of the water these reptiles are agile enough to be able to pursue across the mudflats those little fish called mud-skippers, so named because of the lively way they progress upon their fins.

If intercepted on land, a dog-faced water-snake will flatten itself and hiss threateningly; then if held down, it will strike quite viciously while emitting a most disagreeable smell. Upon being picked up, this snake, though not a constrictor, will exert considerable pressure as it

entwines about its captor's wrist. In captivity it soon settles down, exhibiting a lethargic and inoffensive disposition. Like other aquatic members of the group, the female water-snake gives birth to live young; a brood consists of from eight to twenty-six little reptiles about 7 or 8 inches in length. While now and then an adult may be as much as 4 feet long, snakes of half that size are more frequently encountered.

Though there are nearly a score of different kinds of back-fanged water-snakes to be found in the Pacific region, they are outnumbered by the back-fanged snakes which more or less reside in trees or bushes. The heads of most of these tree-snakes are distinctly larger than the "neck" and their bodies are long, in some species slender and vine-like.

MANGROVE SNAKE

Few, if any, exceed the dimensions of the 7-foot mangrove snake which, despite its size, appears to be harmless to man. One of the commonest and most beautiful of the group, the mangrove snake has an extensive range in the Philippines, Dutch East Indies, and adjacent mainland. Viewed from below, this snake is a dull blue-black, but above it is a rich glossy black with numerous narrow crossbands of bright yellow, their number varying according to locality, for several different races occur on the islands. The lips are yellow, with each lip scale handsomely edged with black.

Mammals (including bats), birds, lizards, snakes, frogs, and occasionally a fish, are all eaten by this snake. Apparently adult snakes prefer warm-blooded prey, while younger ones eat amphibians and reptiles. With more courage than discretion a mangrove snake sometimes attacks a snake as long as itself. One mangrove snake in the Amsterdam Zoo died with the tail of a checkered keelback protruding from its mouth. In Borneo a 4-foot *ular chinchinmas*, as the mangrove snake is called there, was killed and its dinner found to consist of a golden tree-snake that was longer than the diner!

GOLDEN TREE-SNAKE

The coloration of this golden tree-snake is difficult to describe, for it varies according to both locality and age. Young individuals are dark brown or blackish, with many greenish or reddish yellow cross-bars on back and head; as in the mangrove snake, the lips are yellow, usually edged with black. On older snakes almost every scale bears a large greenish yellow spot, so that the black edges of the scales form a kind of network; to enhance further the beauty of this reptile, down the middle of the back there are often red spots arranged in groups of four, like the petals of a flower.

The *ular jelotong*, as the Malays call the golden tree-snake, is common in many parts of the East, including the Philippines and Dutch Indies as far east as Celebes. Flower reckons it among the fiercest of snakes, always ready to attack a disturber instead of gliding quietly away. It resists capture to the last and courageously defends itself with its teeth, but the bites sustained by Flower showed no poisonous effects.

Occasionally this active snake takes up residence in the roofs of houses and decorates the rafters with its delicate discarded "skins." Normally, however, it frequents trees and may be seen on the move during the hottest midday hours. Its prey consists largely of different kinds of geckos, but Malcolm Smith declares that they will devour almost anything that can be overcome. He once saw a golden tree-snake, suspended by its tail from a branch, seize a full-grown mouse, crush it in its coils, and then swallow it—the entire operation being performed in mid-air.

The agility of the golden tree-snake has been noted by many naturalists. One was observed by Malcolm Smith progressing from branch to branch by a series of leaps, some directed upward and each covering about a yard. In preparation for a leap, the snake would coil, then launch itself by suddenly straightening out. However, it is as a "flying snake" that the species has become famous, though it shares this gliding ability not only with a close relative found in the same region, but with the painted bronze-back, a tree-snake with rear

teeth not grooved. Flower relates how he saw a golden tree-snake of moderate size launch itself from a windowsill in the direction of a branch nearly 8 feet away. On alighting, it moved quietly off among the foliage.

Upon receiving reports from Dyak hunters that they had seen golden tree-snakes descend from tall trees by planing to the ground, Robert Shelford set about investigating the matter. Having obtained a living specimen, Shelford carried it out to the veranda of the Sarawak Museum and dropped it from a height of about 15 feet. Much to his disappointment, the reptile fell in writhing coils; a repetition of the experiment had a similar ending. As Shelford recovered the squirming snake, he felt it draw in the broad belly shields which, like those of most tree-snakes, have keels or ridges towards their outer edges. There lay the explanation. Next time he allowed the snake to glide rapidly from his hands, and as it did so the reptile drew in the belly shields and straightened itself out rigidly. Now, shaped like a split bamboo, it glided obliquely earthwards to make a perfect landing. Confirmation of the advantage of this arrangement may be obtained by dropping an entire bamboo section and timing its fall in comparison with that of a split section whose concave undersurface will buoy it up in the air so as to break its fall.

LONG-NOSED WHIP-SNAKE

The golden tree-snake lays from six to twelve eggs, thus differing in its method of reproduction from another Javan tree-snake, which gives birth to as many as twenty-two living young, sometimes enclosed in a delicate membrane, but more often free. This other reptile is likely to attract attention both on account of its extreme slenderness and because its long and narrow head terminates in a flexible tip which has gained it the name of long-nosed whip-snake. Though scarcely thicker than a man's little finger, this whip-snake may reach a length of 6 feet, but such large examples are rare.

In color this whip-snake is rather variable. The commonest type has the upper parts verdant green, while, except for the white or bluish

throat, underneath it is a paler green with a white, yellow, or bluish line along either side of the belly. If angered, a whip-snake quickly changes its whole appearance by inflating the lungs, thus bringing into prominence the black and white skin upon which the separated scales form lines like necklaces of green gems. As if this sudden change were not startling enough, the snake gapes widely to show the pink [1] lining of its mouth, meanwhile turning the lower lip outwards and downwards and spreading the lower jaws widely apart.

If this menacing appearance proves insufficient to prevent the approach of an adversary, the fearless snake watches intently till its enemy's face comes within range, when it makes a dart at the eyes. This habit has gained it the name of "eye snake" in at least one vernacular, and native collectors like to wrap something around a whip-snake's head when bringing a live one into camp. Usually the bite is free from any unpleasant after-effects, but now and again the grooved back teeth come into play. Then there is local pain, followed by numbness and swelling lasting for several days, but unaccompanied by serious constitutional disturbance.

Of course, the venom is not intended for defense, but to assist the reptile in overcoming its prey. Six green frogs and forty-four mice were taken by one captive whip-snake in the course of a year. Small birds, lizards, and other snakes are also eaten.

YELLOW-GREEN WHIP-SNAKE

A very similar whipsnake, but lacking the long nasal appendage, is known as *oraj gadung* at Buitenzorg. Apart from an extensive mainland distribution it is quite the commonest member of its genus in the East Indies and at Palawan in the Philippines. It is a very gentle snake, according to Malcolm Smith, who observes that in common with the long-nosed species it has a trick of remaining for long periods almost motionless with its tongue protruding.

It seems likely that the slowly flickering, and often brightly colored, tongue of a snake may stimulate the curiosity of birds or lizards

[1] Black, according to one author.

and cause them to venture within striking distance of the immobile serpent. The primary purpose of a snake's tongue, however, is to pick up microscopic odoriferous particles from the atmosphere and carry them to receptacles connected with the nerves of smell in the roof of the mouth.

BLUNTHEADS

A few other excessively slender tree-snakes, collectively known as bluntheads, inhabiting southeast Asia and tropical America, deserve mention because they were formerly accorded family status under the name AMBLYCEPHALIDÆ. In recent years the American, then the Asiatic, members of the group have been included in the COLUBRIDÆ of which they form a subfamily called DIPSADINÆ. The only external character separating them from all other members of the COLUBRIDÆ is the absence of a groove between the chin shields (groove present in fig. 38), which, by allowing for expansion, enables colubrine snakes to swallow prey larger than would otherwise be possible.

As it is, the bluntheads confine their diet to grubs, slugs, and snails. Even so they apparently cannot swallow the snail in its shell, as a colubrine snake would do; instead they use their long and delicate teeth to extract the snail from its refuge. The group are well named bluntheads, for their chunky heads, poised on necks which are often no stouter than a piece of string, are a feature which assists in separating them from other slender tree-snakes. Their eyes are unusually large and have cat-like vertical pupils for night vision. All of the dozen species or forms found in the Luchus, Formosa, Philippines, or East Indies, are more or less blotched and mottled in drab tones of gray or brown in support of the illusion of lichen-grown vines produced by their attenuated necks and bodies.

BOA BLUNTHEAD

Dr. E. H. Taylor states that the boa blunthead shows a preference for dead trees, and that when he disturbed one of these snakes it in-

variably fell to the ground and stiffened, then allowed itself to be picked up in this semi-rigid and twig-like condition. This boa bluntheaded differs from all other Asiatic members of the group in having the underside of the tail protected by a single, instead of a double, series of broad shields. It is definitely known from the Philippines, Borneo, Java, Sumatra, and the adjacent mainland. Little seems to have been discovered of the habits of the other species, but it is believed that all of them lay eggs.

7

Poisonous Land Snakes of the Cobra Family

We must now consider the really poisonous snakes. Everyone wants to be able to recognize them, even though poisonous snakes constitute barely a fifth of the 2,500 kinds of snakes to be found in the world. Unfortunately there is but one certain way. Open the snake's mouth, and if you find a pair of much-enlarged fangs in the front, each with an opening on the front surface just above the point, then the species is a venomous one. Sometimes there may be a second pair of fangs close behind the first; these are just replacement fangs waiting to move into place when the others are shed. Occasionally the fangs may be partially concealed by enveloping gum tissue (or *vagina dentis*, fig. 49), which slips up as the snake strikes.

Of course, the problem of recognizing poisonous snakes is much simplified if approached from a regional standpoint, for there will be relatively few poisonous species in any one area. In the United States, for example, one has only to get to know a few types like the gaudy coral-snake, the rattlesnake and its relatives the copperhead and moccasin; these last three all have a characteristic cavity or pit between nostril and eye. By process of elimination, one knows that all other snakes in the United States are harmless.

In an extensive area like the Pacific, ready identification is not so simple, for many of the smaller poisonous members of the family ELAPIDÆ rather closely resemble the harmless colubrid snakes of similar habits to be found in the same region. The quickest way to settle the point is to look for the enlarged fangs. As already indicated in the key (p. 109), these are more or less immovable in the land-

dwelling ELAPIDÆ and marine HYDROPHIIDÆ, while on the other hand, in the vipers (VIPERIDÆ) and pit-vipers (CROTALIDÆ) the very long fangs fold back along the sides of the palate when not in use.

Another noteworthy difference as between the fixed fang and folding fang groups is in the formation of the central canal of the poison fang. In the sea-snakes (fig. 50) and elapids (fig. 51) the canal is formed by an infolding of the tooth which leaves a characteristic fissure or groove down the front surface as far as the orifice for the discharge of the venom. In some species the canal remains open on the surface, in others it is enclosed; the fissure is filled in with calcium, not with dentine or enamel as one might expect, leaving a more or less distinct groove. The very different viperine fang (fig. 52) is described on p. 173.

The venom is secreted in glands which are the counterparts of the salivary glands (parotids) of mammals. In snakes these glands are referred to as modified supralabial glands, for one is to be found on either side of the head lying just above the upper lip behind the eye. This gland is wrapped about by muscles whose contraction at the appropriate moment forces the venom from the gland along the duct leading to the opening at the base of the tooth, and so on down the canal to the outlet near the point. This description is an oversimplification of what occurs, for in a serpent's head other elements besides muscles contribute to the effective working of the perfected mechanism.

KEY TO THE GENERA OF ELAPID[1] SNAKES OF THE PACIFIC

1. Scales along center of back enlarged; range: Borneo south to Sumatra, east to Celebes[2] ..... kraits (*Bungarus*)

   Scales along center of back not enlarged 2

[1] That is to say, land snakes with a pair of enlarged, more or less rigid, grooved (groove open or closed), poison teeth on either side of the front of the upper jaw.

[2] Also Asiatic mainland, the cobras also in Africa.

2. Maxillary bone extending forward slightly beyond the palatine (fig. 53);[1] range: western Pacific east to the Moluccas 3

   Maxillary bone not extending forward beyond the palatine; range: Pacific from Moluccas east to the Fijis 6

3. Internasal scale bordering nostril (fig. 38); 15 to 25 scales around middle of body; spreads a "hood" when alarmed 4

   Internasal scale not bordering nostril; 13 to 15 scales around middle of body; cannot spread a "hood" .. 5

4. A pair of large occipital shields (small in fig. 38); 15 scales around middle of body; range: Philippines south to Dutch East Indies[2] ..... king cobra (*Ophiophagus hannah*)

   No occipital shields; (17) 19 to 25 scales around middle of body; range: Formosa south to Dutch East Indies[2] hooded cobras (*Naja naja* subspp.)

5. Poison glands not extending beyond the head; range: Formosa south to Sumatra[2] ..... Oriental coral-snakes (*Calliophis*)

   Poison glands extending along anterior third of body[3] (fig. 57); range:

[1] This cranial character necessitates opening the mouth and a decision is not always easy in the case of *Calliophis* (inc. *Hemibungarus*) and *Maticora* (inc. *Doliophis*) of section 3, but locality will settle dilemma unless the snake comes from the Moluccas.

[2] Also Asiatic mainland, the cobras also in Africa.

[3] In a freshly killed long-glanded snake this may be ascertained without dissection

Philippines south to Dutch East Indies [1] ..... long-glanded snakes (*Maticora*)

6. Pupil vertical; body thick, short, with 21 to 23 scales around middle; tail compressed toward tip and ending in a long spine; majority of shields beneath tail in a single series; range: Obi; Ceram; and Timor Laut east to New Guinea [2] ..... death adder (*Acanthophis antarcticus*)

Pupil round or almost so; body moderate or slender; tail neither compressed nor ending in a long spine; majority of shields beneath tail in a double series *except in 2 species* .. 7

7. Poison fangs followed by 1 to 7 small teeth 10

Poison fangs followed by 7 to 15 small teeth 8

8. Tail short or moderate with 19 to 41 paired shields below; range: Ceram east through New Guinea and adjacent islands to Bismarck Archipelago [2] ..... Müller's & Schlegel's snakes (*Aspidomorphus*)

Tail moderate or long with 61 to 105 mostly paired shields below .. 9

9. Scales on back each bearing a ridge or keel; 21 to 23 scales around middle of body; 61 to 78 (pairs of)

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by feeling for the displaced heart in the middle third of body, instead of in anterior third as in the corals.

[1] Also Asiatic mainland.

[2] Also Australian mainland.

	shields beneath tail; range: New Guinea[1]	taipan (*Oxyuranus scutellatus*)
	Scales on back quite smooth; 15 scales around middle of body; 69 to 105 (pairs of) shields beneath tail; range: Yule Island and New Guinea[1]	whip-snake (*Demansia psammophis* subspp.)
10.	Belly shields more than 160 (164 to 328)	11
	Belly shields less than 160 (139 to 152)	19
11.	Eye moderate or small, its diameter about equal to, or included 1½ times in, its distance from the mouth	12
	Eye very small, its diameter included 2 times in its distance from the mouth	14
12.	Belly shields more than 180 (199 to 233); eye moderate, its diameter about equal to its distance from the mouth; range: New Guinea[1]	mulga snake, etc. (*Pseudechis*)
	Belly shields less than 180 (164 to 179)	13
13.	Eye moderate, its diameter about equal to its distance from the mouth; back of head and nape colored uniformly with back; range: Solomons[1]	Guppy's and Woodford's snakes (*Denisonia*)
	Eye small, its diameter included about 1½ times in its distance from the	

[1] Genus also on Australian mainland.

mouth; back of head and nape much paler than snout and back; range: Aru Islands, Dutch East Indies, west through New Guinea to islands of Torres Straits[1] ..... brown-headed snake (*Glyphodon tristis*)

14. A preocular (for name only, see fig. 38) separating prefrontal from lip shields; belly shields 165 to 223 .. 16

No preocular, the prefrontal in contact with a lip shield; belly shields 230 to 328 15

15. Nostril between 2 nasals (fig. 38); 15 to 17 scales around middle of body; range: New Guinea; Woodlark and Ferguson's Islands ..... *Toxicocalamus*

Nostril in a single nasal; 13 to 15 scales around middle of body; range: New Guinea and Seleo Island .... *Ultrocalamus*

16. Nostril between 2 nasals 17

Nostril in a single nasal 18

17. Pupil said to be "vertically elliptic" (for shape only, see fig. 37); range: New Guinea ..... *Apistocalamus*

Pupil round; range: New Guinea and Solomons ..... *Micropechis*

18. Belly shields 196 to 205; anal shield divided; range: Sattelberg, New Guinea ..... Nyman's snake (*Pseudapistocalamus nymani*)

[1] Genus also on Australian mainland.

Belly shields 165; anal shield entire; range: Bougainville, Solomons .... Hediger's snake (*Parapistocalamus hedigeri*)

19. Belly shields 139 to 152; anal shield divided; scales beneath tail 27 to 38 pairs; range: Fijis ..... Fiji snake (*Ogmodon vitianus*)

KRAITS

Largely on account of the handsome banding or striping of the commonest species, the glossy-scaled kraits are almost as well known as the cobras. They are familiar also because in their wanderings they enter houses and seek to conceal themselves in bathrooms, cupboards, or between the slats of shutters, and show a preference for cultivated country where barefooted natives are at work.

Though the glands of a krait may carry sufficient venom to kill five men, deaths from krait bite are relatively uncommon. This is due to the inoffensive disposition of the kraits, for, short of being trodden upon or otherwise forcibly restrained, they seem strangely reluctant to use their lethal powers. These are reserved for the snakes, both harmless and venomous, upon which kraits subsist. When its favorite snake food is not forthcoming, a krait will eat small animals, lizards, toads, frogs, and even fish. Four human beings bitten by kraits have succumbed in five and a half, ten, twelve, and fifteen hours respectively.

Only five of the dozen Asiatic species occur on Pacific islands, but in Borneo the yellow-headed krait has a mountain race that is strikingly banded in coral-red and iridescent black in sharp contrast to the striped form of the lowlands. The five species are not difficult to recognize.

Key to the Kraits of the Pacific

1. Scales around middle of body 13; back with ridge; shields beneath tail partly single, partly

paired (as in fig. 47); range: Borneo; Sumatra; Java [1] ..... yellow-headed krait (*Bungarus flaviceps*)

Scales around middle of body 15 to 17; shields beneath tail in a single series 2

2. Back with a ridge; tail ending bluntly; range: Borneo; Sumatra; Java [1] ..... banded krait (*B. fasciatus*)

Back without a ridge; tail ending in a point .. 3

3. Back without crossbars; range: north coast Java Javan krait (*B. javanicus*)

Back with numerous white crossbars, the center portion of each bar spotted with black 4

4. Back with 20 to 25 broad white crossbars; range: Sumatra; Java; Celebes [1] ..... Malayan krait (*B. candidus*)

Back with 27 to 48 narrow white crossbars; range: Formosa [1] ..... many-banded krait (*B. multicinctus*)

BANDED KRAIT

Best known of the five is the banded krait, a canary-yellow reptile with brownish snout and a black spearhead-like marking commencing between the eyes and extending far back along the neck; the body is ringed with saddle-like markings as broad as, or broader than, the yellow interspaces. Usually banded kraits are about 4 feet long, but an occasional specimen may reach 6 feet; even so in length it is sometimes surpassed by the yellow-headed species.

Both kinds present a rather emaciated appearance owing to the ridge along the back. In captive kraits this appearance is likely to become even more accentuated, for some of them refuse food and none

[1] Also Asiatic mainland.

have survived six years' captivity. Kraits are thirsty reptiles and their search for water leads them to swampy rice fields and sometimes ends by their falling into wells.

So far as is known, all kraits lay eggs beneath rubbish or in holes in the ground. During digging operations one rather emaciated female was exhumed together with her eight eggs, which measured about 2⅓ by 1½ inches, and from some of which the young had emerged. Curiously enough, the guardian mother showed no concern when the young were interfered with. Even when she herself was touched, her only response was to hiss and flatten her body in surprising fashion. Apart from this reaction, a banded krait seldom attempts to strike and rarely to escape even if provoked by poking. Instead, it usually endeavors to conceal its head beneath a few loose coils of the body. If further annoyed, the snake's sole response is likely to be a few convulsive jerks and a shift in position.

KING COBRA OR HAMADRYAD

Kraits, though snake-eaters themselves, are preyed upon in turn by the hamadryad or king cobra. This magnificent reptile is well named, for in size it surpasses all other poisonous snakes in the world. Though rarely exceeding 14 feet in length, the head of an 18-foot, 4-inch specimen from peninsular Siam is in the Museum of Comparative Zoölogy at Harvard. This reptile was shot by a trained Dyak collector, who took the measurement by laying his gun along the snake.

Fortunately this deadly snake appears to be uncommon on most of the islands where, being a good climber, it haunts both thick jungle and relatively open country in the vicinity of streams. When disturbed by man, a king cobra usually departs, but at times, with no apparent reason unless it is that the intruder is between the snake and its hole, the reptile will rear up and make an unprovoked attack. Possibly this aggressiveness is connected with the breeding season, or with guarding the eggs in which the male sometimes plays a part.

The twenty-one to forty eggs are deposited in piles of leaves or vegetable debris, and the guarding mother lies coiled above them

though separated by a layer of leaves. In one instance, fourteen people and their seven dogs twice passed within 6 feet of a nest, quite unaware of the presence of the completely concealed snake. On hatching, the young measure about 20 inches, and being strikingly banded with black and white, or with light crossbands formed of a series of yellow spots, they may not be recognized as king cobras.

Adult hamadryads, known as *ular tedong selar* in Borneo, *ular anang* in Java, have brown heads with some of the scales margined with black. The body is yellowish or olive-brown with or without numerous black-edged, pale bands; the proportion of black tends to increase towards the tail, which may be almost wholly black with light crossbands. The chin and throat are often tinged with yellow or tangerine.

We are so accustomed to seeing photographs of cobras with their hoods spread that many people do not realize that normally a cobra looks like any other snake. It is only when startled or enraged that a cobra rears the forepart of its body and, by raising its unusually long forward ribs, distends the skin to form the "hood." Because of its great length, a king cobra can rear up till its head is level with a man's face, but its hood is relatively narrower than that of the common cobra.

COMMON AND SPITTING COBRAS

Unfortunately cobras are exceptionally variable in both color and markings, and in the Pacific region particularly it is difficult to assign definite ranges to the various forms. All of the Pacific island forms appear to be races of the common cobra of India, but, except in very young individuals, one looks in vain for anything approaching the spectacle-like markings so characteristic of the hood of the typical Indian race. Instead, we find adult cobras which may be uniformly olive, brown, gray, or black above, while below their throats may be white or yellow, with or without one or two black bars prominently displayed *beneath* the hood as the reptile rears to face the object of its alarm or wrath. Younger cobras may or may not have conspicuous white crossbars on the hinder portion of the body and tail.

At least one form of cobra found in the Philippines and East Indies does not always wait for its enemy to come within striking distance. Throwing back its head to the correct angle, it ejects the venom from its fangs with such force that the twin jets of fluid carry to a distance of 6 feet or more. The discharge of the poison is accompanied by a sharp hiss that has the effect of spraying the venom at the face of the snake's opponent.

Should the poison fall upon the bare skin—and I have had it on my neck and arm several times—it is harmless unless one has just shaved or there is a cut or abrasion present. Its effect on the eyes, towards which it is normally directed, is instantaneous agony. Blinding tears course over the burning eyeballs as the venom is rapidly absorbed by the tiny superficial blood vessels. Unless the venom is washed off promptly with a weak solution of potassium permanganate, boric acid, milk, or even plain water, the sight may be permanently affected. If the venom is thoroughly washed off, there need be no unpleasant after-effects.

Dogs that have been targets frequently go blind, for being closer to the cobra, they receive a more copious discharge of the poison. Lieutenant Gibson, when stationed in Burma, saw a cobra as he was crossing the camp to his quarters. After calling for a light and stick, he bent over to hit the reptile but it "spat" in his face. In addition to the immediate pain, his eyelids were said to have swelled rapidly to the size of a large hen's egg, but after an unhappy night in hospital he recovered his sight. One of my friends when stooping to swat a cobra received some of the bitter-tasting venom in his open mouth; fortunately his eyes were saved by the glasses he was wearing, and no symptoms of poisoning developed.

While cobra venom is extremely toxic, a gratifying proportion of persons bitten recover for reasons which will be discussed later in the chapter dealing with venoms and the treatment of snake bite. Deaths from this cause in the Philippines are chiefly attributable to cobras, according to Taylor, though it is generally agreed that the cobra is not an aggressive reptile. Its poison is primarily intended to enable the

snake to overcome its warm-blooded prey such as rats, mice, and birds, but snakes, lizards, toads, and frogs are also taken.

A fondness for chicks and eggs leads cobras to invade henhouses whenever they can find a rat-hole or other means of entry. One cobra that gained admission through a crevice gorged on a nestful of eggs to such an extent that it could not escape through the exit but was found next morning in a surfeited condition, half in, half out. The snake was promptly killed and cut open, and as the swallowed eggs were unbroken and still warm, they were returned to the broody hen, which successfully hatched them. The incident is not as unique as might be supposed. Experiments have shown that it takes the gastric juice of a cobra two days and nights to dissolve away the shell from a fowl's egg.

As they eat eggs so readily, it is not surprising that captive cobras can be trained to take dead food. Dr. Frank Wall writes of the avidity with which a cobra accepted mice from its master, a snake-charmer of Bangalore. The juggler withdrew the mice from his pocket one at a time and proffered them to his snakes much as one might offer some tidbit to a dog. One cobra "nosed its snout into his hand and took three mice" one after the other, and swallowed them in quick succession.

Itinerant snake-charmers and their "pets" are met throughout the East, and their arrival usually launches a discussion as to the strange relationship between man and reptile. "How is it the man is not bitten?" someone will ask, or "Why do the cobras respond to his music if they have no ears?" Before answering, we can dismiss from our minds the whole idea of the possibility of a snake being "charmed."

The chief factor in the performance is the marvelous skill with which the juggler avoids being bitten. This is largely due to a careful study of each snake's disposition and an intimate knowledge of their ways resulting from a lifelong association with the reptiles. Undoubtedly some of the less proficient members of the juggling fraternity seek protection by removing the poison fangs, an operation which usually makes the snake less willing to bite. Should it do so, there is still some

risk from venom gaining admission through lacerations caused by the smaller teeth. Moreover, unless serious injury has been done to the cobra's mouth, new poison fangs may move into position and be ready to function within eighteen days after the loss of the previous pair.

Cobras are nervous reptiles and, as already stated, the defensive attitude in which this snake rises and spreads a hood is assumed in response to fear and anger. It is from this position that a cobra strikes. Snake-charmers know that their snakes will become accustomed to them after a time and fail to rise when the lid of their basket is removed. In other words, let their owner pipe on his flute as much as he likes, the reptiles refuse to respond and will have to be prodded into contributing their share to the entertainment. For this reason professional charmers continually replenish their stock with freshly caught cobras.

As the Hindu performer, playing his pipe, squats swaying before them, the onlookers observe that the cobras too are swaying as if keeping time with the tune. Actually the alert reptiles are only following the motions of the musician's body, ready to strike if need be. That they have no "ear for music" has been demonstrated by Wall, who covered the eyes of some cobras with adhesive tape and then noted their quiescence and absence of reaction to music or even such loud sounds as banging on a can or drum. These blindfolded cobras still showed a snake's normal sensitiveness to vibrations communicated through the medium of solid objects, for they rose immediately in response to a heavy footfall in their vicinity.

It is on the feet or legs that most people get bitten, for during hot weather barefoot natives journey by night so as to take advantage of any drop in temperature. Cobras, though largely diurnal, become nocturnal in areas where large human populations cause frequent disturbance by day. During its wanderings on a cool night, a snake that comes to a path or road that retains heat from the solar rays is likely to stretch out to enjoy the congenial warmth and may not rouse at the approach of bare feet until trodden upon.

So adaptable are the cobras that no type of country can be con-

sidered as especially favored by them. They may install themselves in an old termite-hill or holes among the roots of a big tree. Ruins of any kind are sure to provide a refuge, but their search for food will carry cobras into suburban gardens and human habitations as well as to timber-yards and warehouses. Cobras, being sociable reptiles, at times live with members of the same sex, but in pairs during the mating period.

The period of gestation has been accurately ascertained as ranging from two to nearly five months. The soft-shelled oval eggs number from twelve to twenty-two and may take from forty-nine to sixty-nine days to hatch. Taylor describes the hatching of a batch which had been placed in moist earth. After rupturing the parchment-like shell, the little cobra pushed the forepart of its body up through the soil till its head was free, though the hinder portion of the snake remained within the eggshell which still retained a good deal of fluid. In this position the snake would remain for hours until disturbed, when it withdrew wholly within the eggshell. Eventually egg and snake were removed to the surface. This caused the young cobra to emerge partially and rear, with spread "hood," to strike at anything moved near it. Three or four days elapsed before the young snakes voluntarily left their eggshells, and when they did so it was to seek refuge in a small water vessel. There, with bodies closely entwined and only their snouts showing above the surface of the water, they remained for more than a week. On leaving the water they took cover under various objects in their cage and proceeded to cast their "skins" for the first time. It was only after this was accomplished that they began to feed on tadpoles and then on frogs. Some idea of the quality of their venom at this tender age may be gained from the fact that a five-day-old cobra bit a guinea pig, which died twenty-two minutes later.

Cobras measure about a foot in length. When they hatch, they may go on growing till they reach 6½ feet, but this is the record, and specimens two-thirds the maximum length are sizable snakes. The record for longevity is held by two cobras, kept by the New York Zoological Society, which lived in captivity for over twelve years.

ORIENTAL CORAL-SNAKES

The cobras' relatives, the Oriental coral-snakes, appear to be of an even more amiable disposition than their American allies, for I have never read of a man being bitten by one of them. Little is known of their habits, however, and no chances should be taken, for a bite, if given, is likely to be sudden. During the day these coral-snakes conceal themselves beneath leaves, logs, or in the earth, emerging at night to go in search of their prey, which consists of smaller snakes like the dwarf snakes, some of which show a marked resemblance to the coral-snakes themselves. Presumably these Oriental coral-snakes lay eggs, but as some unlaid eggs have been found to contain embryos, an element of uncertainty remains.

All half-dozen species occurring on Pacific islands are relatively small, scarcely equaling a man's little finger in diameter. Not one of them reaches a yard in length, while most of them average about half that size. The following synopsis may assist in recognizing them, but it is well to remember that among such secretive snakes their ranges are likely to be extended and undescribed forms may yet be discovered.

Key to the Oriental Coral-snakes of the Pacific

1. Scales in 15 rows; anal entire (as in fig. 46); 2 preoculars (fig. 38); range: Philippines .... beautiful coral-snake (*C. calligaster*)

   Scales in 13 rows; 1 (rarely 2) preoculars .. 2

2. Anal entire; temporals 2 + 2 (fig. 38); range: Philippines ..... McClung's coral-snake (*C. mcclungi*)

   Anal divided; temporals 1 + 0, 1 + 1, or 1 + 2 3

3. Temporals 1 + 0; belly shields more than 300; range: Sumatra [1] ..... graceful coral-snake (*C. gracilis*)

[1] Also Malay Peninsula.

Temporals 1 + 1 or 1 + 2 4

4. Back and sides without longitudinal black lines 5

Back and sides with 1, 3, or 5 longitudinal black lines 6

5. Temporals 1 + 1; range: Formosa ..... Swinhoe's coral-snake (*C. m. swinhoei*)

Temporals 1 + 2; range: Luchus ..... Iwasaki's coral-snake (*C. m. iwasakii*)

6. Black side line interrupted by vestigial black crossbars edged with yellow; range: Luchus .. Striped coral-snake (*C. j. japonicus*)

Black side line uninterrupted; range: Formosa Sauter's coral-snake (*C. j. sauteri*)

LONG-GLANDED SNAKES

While Oriental coral-snakes have the poison glands confined to the sides of the head just behind the eye, in the long-glanded snakes the venom glands extend along each side of the body for nearly a third of its length (fig. 57), thickening towards their ends, which lie just in front of the displaced heart. Unfortunately, there is no ready means of distinguishing a preserved long-glanded snake from an Oriental coral-snake. A freshly caught example may be recognized by feeling for its heart, which will be found in the middle third of the body, that is, situated much farther back than is normally the case with snakes like the oriental coral-snake in which the heart is in the anterior third of the body.

Nothing is known of the effects of the poison contained in these extraordinary glands, but the various species of long-glanded snake *appear* to be as inoffensive as the coral-snakes. Taylor, who hunted them in the Philippines, tells us that when he exposed them by rolling back the rotting logs beneath which they had been concealed, the reptiles lay still and made no attempt to escape. If touched they commenced a series of gyrations in which the writhing snake flung itself

about until the body left the ground. One reptile might lie on its back so as to expose its red or yellow belly strikingly barred with black, or just turn up the tip of the tail to display its red underside. When the snake does decide to retire, it carries this tail upraised like a head about to strike, so that the retreating reptile appears to be wriggling backward in the manner already described for the quite unrelated and harmless cylinder- and dwarf-snakes.

There are three species of long-glanded snakes known, but two of these have several races on the islands. Unfortunately, none of these have English names, so it has been necessary to suggest those given in the following key.

KEY TO THE LONG-GLANDED SNAKES OF THE PACIFIC

1.	Diameter of eye about half as long as its distance from the mouth; range: Philippines	Philippine long-glanded snake (*Maticora philippinus*)
	Diameter of eye much more than half as long as its distance from the mouth	2
2.	Shields beneath tail in 15 to 33 pairs; range: Philippines southwest to Sumatra and east to Celebes[1]	common long-glanded snake (*M. intestinalis* and races)
	Shields beneath tail in 34 to 50 pairs; range: Borneo; Sumatra; Java and adjacent islands	red-bellied long-glanded snake (*M. bivirgatus* and races)

The Philippine species agrees with the common long-glanded snake on those islands in having the underside crossed by many black bars, each of which covers two or three belly shields. But one Sarawak race of the common long-glanded snake lacks the crossbars; its belly is uniformly crimson like that of all forms of the red-bellied reptile. Of this species one variety has no stripes on the back and lower flank, or

[1] Also Malay Peninsula.

just one on each flank. The Bornean race, on the other hand, must be a beautiful creature in life, for its head, tail, and belly are bright crimson, in rich contrast to the slate-blue body which has two narrow light blue lines running the length of the back, while on either flank is a broader white one with a narrow blue one immediately below it. These blues, reds, and yellows disappear after the snake has been preserved for a few weeks or months. This four-lined Bornean race attains a length of 5 feet, has a wide gape and relatively long fangs, and must certainly be regarded as potentially dangerous.

DEATH ADDER

The name "adder" is so rarely applied to members of the cobra-coral snake family that, until seen, one wonders why a common Australian elapid should be designated "death adder." To a European it is quite an appropriate title, for the heavy-bodied reptile has a broad head that is sharply distinct from the neck, and an almost rat-like tail that tapers abruptly from the body to terminate in a long spine (fig. 42). Its superficial resemblance to a thickset adder, rather than to the moderate-headed, slender-bodied cobras, is immediately apparent. In length it is usually about 18 inches, though death adders sometimes grow to be a yard long.

Its brownish or drab gray color, with darker crossbands, assists in rendering the reptile inconspicuous as it lies half-buried among leaves and sand awaiting nightfall. For death adders, as may be guessed from the shape of the pupils of their eyes, are nocturnal. It is in their apparent sluggishness that the chief danger lies so far as man is concerned, for a death adder will remain motionless until an unwary hand or foot comes within its 9-inch range, when it strikes with startling suddenness.

Though the fangs are rather short, the venom is potent and causes death by asphyxiation produced by the paralysis of the muscles which operate the diaphragm. Except to a slight extent, the death adder's poison is deficient in the blood-coagulating and -destroying properties associated with the venom of the true adders or vipers. This is what

might be expected, for its affinities are with the cobras. Yet in the matter of reproduction it resembles the adders or vipers in giving birth to living young, about a dozen at a time.

MULLER'S AND SCHLEGEL'S SNAKES

Two very closely related snakes of the genus *Aspidomorphus* (formerly called *Pseudelaps*), though common in New Guinea, have long been confused with one another until L. D. Brongersma showed that they might be distinguished as follows:

Upper part of head sprinkled with larger and smaller, roundish or oval, light-edged dark spots; side of head showing a light band broadly interrupted by an oblique dark bar below the eye; range: New Guinea to New Britain and adjacent islands	Müller's snake (*Aspidomorphus mülleri*)
Upper part of head without, or at most with only a few small, spots; side of head showing a light band not interrupted by an oblique bar below the eye; range: New Guinea (particularly the western half) and islands on the Sahul shelf ..	Schlegel's snake (*A. schlegelii*)

While the head of Müller's snake is an olive hue, that of Schlegel's tends to be brownish like the body. The bodies of both species may be uniform brown or gray, but both are extremely variable and Müller's differs from island to island. This is the larger reptile, for some are as much as 2½ feet in length; Schlegel's aspidomorphus, on the other hand, is not known to exceed 1½ feet. Consequently neither seems likely to be a menace to man, though they must be regarded as potentially dangerous.

TAIPAN

But of the taipan no doubts can be entertained, for it is generally conceded to be the most dangerous of Australian snakes. Fortunately for the continent "down under," it appears to be confined to the Cape York Peninsula; its inclusion in this handbook rests on a single record of one taken near the Fly River, New Guinea.

It is not merely on account of its size—10 feet—that the taipan is feared, but because of the dread with which it is regarded by the aborigines, who charge it with being responsible for many deaths among them. D. F. Thomson, who secured six living taipan in northeast Australia, says that it is an aggressive reptile. When about to attack, a taipan raises its head and several coils clear of the rest of its body. At the same time the head is depressed until the angles of the jaws project, and the tail is raised and waved to and fro. This threatening performance presages a series of strikes which are delivered with such suddenness and rapidity that the startled victim has little chance of escaping three or four bites from the ½-inch fangs. Thomson noted in the field that the greater part of available venom is voluntarily discharged in the preliminary bites, so that immediately after capture little can be expressed by pressure on the glands.

One of the captured snakes had three eggs in the oviducts. Of these the biggest measured rather more than 1½ by 3 inches, being somewhat larger than seven others laid between September 27 and October 6 by another of the snakes. The taipan is to be found in the savanna forest and inland plains, but appears to be most numerous on parts of the coast which are infested with rats, upon which it feeds.

SPOTTED-HEADED SNAKE

According to Thomson, in its habits the taipan resembles its near relative the "black whip-snake," and since Thomson secured thirty-five whip-snakes he had excellent opportunities for observing both. As these snakes vary from blackish and reddish brown to olive, the local name may be rather misleading at times; "spotted-headed snake" is

better. The underside of this species may be plumbeous or olive, with the margins of the scales darker. Perhaps more than one race occurs in New Guinea, but this point cannot be settled until numerous specimens are available for study.

Recently obtained examples show that this reptile may grow to a length of 6 feet; formerly 3 feet was considered nearly maximum. Cape York natives claim that most aborigines bitten by this whip-snake recover, for the amount of venom available is usually small. The yield of venom is proportionately greater for big snakes, and no chances should be taken with them. When disturbed, this whip-snake relies on its speed to escape, but if cornered, according to Thomson, it will deliver a series of short quick snaps.

MULGA SNAKE

In this it differs from the mulga snake and its relatives of the genus *Pseudechis*, which usually hold on when biting. A mulga snake emerged from a hole among the roots of a large gum to lie by the feet of de Teliga as he sat skinning birds for the Museum of Comparative Zoölogy. When he moved slightly, the snake struck at his leg and penetrated the trousers but failed to reach the skin, though venom was spilled upon it. Mulga venom is very destructive to blood, but its toxicity is not great; in fact, it is only a tenth to a seventieth that of the Australian tiger snake. Aborigines claim that the bite is not fatal for a man though it is for a dog; their opinion appears to be substantiated by the controlled laboratory experiments of C. H. Kellaway.

The venom is quite adequate to overcome the small creatures—rats, mice, bandicoots, lizards, and snakes—upon which a mulga snake feeds. The mulga snake grows to a length of 6 feet and is uniformly olive-brown to coppery brown. Generally some of the shields on the underside of its tail toward the tip are arranged in pairs, but in one snake from Merauke, New Guinea, all the subcaudals, as they are called, are single. A second species occurs on New Guinea but the two can be readily separated by making a count of the scales around the middle of their bodies, thus:

Scales around middle of body in 17 rows ..... mulga snake (*Pseudechis australis*)

Scales around middle of body in 19 to 21 rows .. Papuan pseudechis (*P. papuanus*)

GUPPY'S AND WOODFORD'S SNAKES

East of New Guinea in the Solomons are two allied snakes of the genus *Denisonia* with 15 to 17 scales around midbody: they may be separated by seeing whether

Shields under tail are mostly single; range: Faro; Guadalcanar; Howla; Melanta; Ysabel ..... Guppy's snake (*Denisonia par*)

Shields under tail are paired; range: New Georgia; Rendova; Tetipara; Vangunu, etc. ..... Woodford's snake (*D. woodfordii*)

In Guppy's snake the head is dark colored but the body may be yellowish white, pink, reddish, brown, gray, or black, with or without red-brown crossbars. So variable is it that an occasional individual may approach the coloring of Woodford's snake, which is pale sandy brown, each scale edged darker to produce a reticulated effect. Neither species apparently exceeds a yard in length, and nothing seems to be known of their habits.

With a few exceptions, most of the elapid snakes yet to be discussed are of small size and little is known of their manner of life or the effects of their venom. Brief summaries of their appearance as a supplement to the information contained in the key, are offered to aid in recognition.

BROWN-HEADED SNAKE

The brown-headed snake usually has a yellowish or pale reddish patch on the back of its head and nape; the dark brown or blackish scales on its back have pale edges, a reversal of the arrangement described for Woodford's snake. The brown of the back and flanks

impinges on the otherwise yellow scales of the belly, while the front portion of the tail is brown below. Length 3 feet.

TOXICOCALAMUS

The two species of *Toxicocalamus* may be recognized as follows:

Midbody scales in 17 rows; belly scales 274 to 305; range: Ferguson and Woodlark Islands, New Guinea — elongate snake (*T. longissimus*)

Midbody scales in 15 rows; belly scales 230 to 261; range: Owen Stanley Mountains, 2,000 to 4,000 feet — Mt. Stanley snake (*T. stanleyanus*)

The elongate snake is grayish brown above with whitish sides; across the snout is a reddish bar, and there is a spot of the same color behind the eye. The whitish lower surface is relieved by two dark longitudinal lines. Its relative from Mount Stanley is rather similar, being blackish brown above with the two lower scale rows white except for a black spot in the center of each scale. The dark coloring of the top of the head descends to form two vertical bars on the yellowish upper lip; on the neck is a yellow collar edged with black. Below the snake is white except for a black spot on the side of each belly shield, some of which may be bordered with black.

APISTOCALAMUS

From New Guinea five species of *Apistocalamus* have been described, several from a single example. When more specimens are available, it is possible that some of these "species" will have to be united. An idea of their overlapping can be gained from the following list.

Belly shields 173 to 193; subcaudals 28 to 46; range: Mount Lamington district ..... Mt. Lamington snake (*A. lamingtoni*)

Belly shields 190; subcaudals 41; range: Owen Stanley Mountains at 4,000 feet ..... Pratt's snake (*A. pratti*)

Belly shields 196; subcaudals 50 or more; range: Haveri, Moroka ..... Lori's snake (*A. loriæ*)

Belly shields 199 to 218; subcaudals 22 to 32; range: north of Fakfak at 1,700 feet ..... Lönnberg's snake (*A. lönnbergi*)

Belly shields 207; subcaudals 27; range: Setekwa River ..... giant apistocalamus (*A. grandis*)

Young examples of the Mount Lamington species display a yellow collar like the type of Lönnberg's snake; the adult, however, resembles both Lori's and the giant apistocalamus in not having a collar; Pratt's snake presents an intermediate condition with a streak of yellow on either side of the nape where the others have a collar.

MICROPECHIS

The two species of *Micropechis*, of which the larger grows to 5 feet, are possibly distinguishable only on color and pattern.

Temporal scales 2 + 2; head and tail black above, anterior third of body uniform yellowish, on the posterior third each scale is black edged with yellow. Below, yellow, uniform, or some shields edged with black; range: New Guinea ..... Ikaheka snake (*M. ikaheka*)

Temporal scales 1 + 2; end of snout and eye region black, above cream color with 22 black bands, on posterior part of body small black spots form a streak along either side of back. Below, whitish, uniform on body but tail ringed with black; range: Solomons ..... banded snake (*M. elapoides*)

PSEUDAPISTOCALAMUS

Nyman's snake is iridescent blackish or bronze-brown on the back, but the sides are lighter; a yellow band crosses the front part of the head to join the yellow upper lip; there is also a yellow spot on either side of the neck as in Pratt's snake, to which it seems closely related. A 16-inch female Nyman's snake held eggs that measured about ½-inch in length.

PARAPISTOCALAMUS

Hediger's snake, known only from the original foot-long specimen, is said to be blackish gray above except for the row of scales next to the belly shields. These are white like the sides of the head and underside except for the throat and lower surface of the tail, which are lightly washed with gray.

OGMODON

The Fiji snake, the only poisonous *land* snake on the Fiji Islands, varies from blackish to dark brown above, but is a somewhat lighter brown upon the sides; young snakes have a yellow blotch on the crown of the head. The lower surface of the body may be either brown or white, more or less spotted with black, while the tail is entirely black. The total length of the Fiji snake is only about 15 inches.

8

Poisonous Sea-Snakes

WE now come to the sea-snakes; of their gregariousness an interesting account has been furnished by that veteran naturalist, Willoughby P. Lowe, in his book *The Trail That Is Always New.*[1] On p. 43 Lowe writes:

"Leaving Colombo we departed for Penang, and the voyage from now on became more interesting, as there was a good deal to be seen, such as rocks covered with sea-birds, chiefly Gannets and Shearwaters. To starboard lay the beautiful green island of Sumatra, and to the port the Malay Peninsula. The water now became very calm and oily in appearance. After luncheon on 4th May I came on deck and was talking to some passengers when, looking landward, I saw a long line running parallel with our course. None of us could imagine what it could be. It must have been four or five miles off. We smoked and chatted, had a *siesta,* and went down to tea. On returning to the deck we still saw the curious line along which we had been steaming for four hours, but now it lay across our course, and we were still very curious as to what it was. As we drew nearer we were amazed to find that it was composed of a solid mass of sea-snakes, twisted thickly together. They were orange-red and black, a very poisonous and rare variety known as *Astrotia stokesii.* Some were paler in colour and as thick as one's wrist, but the most conspicuous were as thick as a man's leg above the knee. Along this line there must have been millions; when I say millions I consider it no exaggeration, for the line was quite ten feet wide and we followed its course for some sixty miles. I can only presume it was either a migration or the breeding season. . . . It certainly was a wonderful

[1] London: Gurney & Jackson, 1932.

sight. As the ship cut the line in two, we still watched the extending file of foam and snakes until it was eventually lost to sight."

There is no mistaking a sea-snake with its paddle-shaped tail (fig. 43) for any other member of the serpent tribe; it is more usual to confuse them with eels, but these have smooth and slimy skins instead of a scaly covering. It is another matter to devise a simple key to assist in distinguishing the forty kinds of sea-snakes found in the Pacific. Even an attempt to define the sixteen generic groups into which sea-snakes are divided cannot be achieved without recourse to a few semi-technical references to jaws and teeth. It is hoped, however, that the following synopsis may be useful.

KEY TO THE GENERA OF SEA-SNAKES IN THE PACIFIC[1]

1. Belly shields large, one third to over half the body width 2

   Belly shields small, not more than one quarter of the body width (except in *Hydrophis mertoni*), or absent 5

2. Nostrils open sidewards; nasal shields separated by internasals; range: Japan southwest to Sumatra east to the Fijis and Savage Island ..... *Laticauda*

   Nostrils open upwards; nasal shields in contact with each other 3

3. Upper lip bordered by 3 shields on each side; no maxillary teeth following the fangs; range: Formosa and Luchus east to Loyalty Islands.... *Emydocephalus*

   Upper lip bordered by 6 to 10 shields on each side; 5 to 11 maxillary teeth following the fangs 4

4. Belly shields one third to half the body width; maxillary bone extending forward beyond the

[1] Ranges extending to other oceans not included.

palatine (as in fig. 53); range: Sumatra east to New Caledonia ..... *Aipysurus*

Belly shields nearly as broad as the body width; maxillary bone not extending forward beyond the palatine (fig. 55); range: northwest Australia ... *Ephalophis*

5. Belly shields small but distinct throughout, normally entire (see also *Kerilia jerdoni*; *Lapemis curtus*) 6

Belly scales, except on the forward portion, either divided longitudinally and usually smaller than the adjacent scales, or absent, *i.e.* not distinguishable (except in occasional specimens of *Kerilia* and *Lapemis*) 11

6. Head shields normally regular, the nasal shields in contact with each other 7

Head shields more or less divided posteriorly .. 10

7. No preocular shield in front of eye; range: northern Australia ..... *Hydrelaps*

A preocular shield in front of eye 8

8. Chin shield very long, partly hidden in a groove; range: (? Japan); Borneo and Malay Straits east to New Guinea ..... *Enhydrina*

Chin shields normal 9

9. Belly shields of uniform width throughout; range: Japan southwest to Sumatra east to the Fijis .... *Hydrophis*

Belly shields broad on front of body, narrower on hinder part; range: Borneo south to Java .... *Thalassophina*

10. Body scales large, 31 to 35 around middle of body; forming regular rows; range: Borneo south to Java, east to the Moluccas ..... *Thalassophis*

    Body scales small, 70 to 90 around middle of body; in irregular rows; range: Java Seas ..... *Kolpophis*

11. 23 scales or less (19 to 23) around middle of body; maxillary bone extending forward beyond palatine (as in fig. 53); a series of teeth following close behind fangs; range: Borneo to Malay Straits .. *Kerilia*

    23 scales or more (23 to 67) around middle of body 12

12. Shields above and behind eye spiny; range: (? Hong Kong) east to Torres Straits, New Guinea ..... *Acalyptophis*

    Shields above and behind eye without spines 13

13. Less than 45 (25 to 43) scales around middle of body 14

    More than 45 (47 to 67) scales around middle of body 15

14. Head very small; body long and very slender in its forward portion; maxillary bone extending forward as far as or a little farther than the palatine (as in fig. 53); range: Hainan south to Sumatra and Java (possibly east to Australia) ..... *Microcephalophis*

    Head not small; body not long nor particularly slender in its forward portion; maxillary bone not extending forward as far as the palatine; range: Japan southwest to Sumatra east to New Guinea and the Queensland coasts ..... *Lapemis*

15. Back scales pointed and strongly overlapping; belly shields in two halves; range: China Sea east to Torres Straits, New Guinea ..... *Astrotia*

Back scales neither pointed nor overlapping but forming a mosaic; belly shields, if at all larger than the adjacent scales, with a median groove; range: southern Siberia southwest to Sumatra east to Samoa and Panama ..... *Pelamis*

COMMON BANDED SEA-SNAKE

As may be guessed from the preceding key, the broad belly shields of members of the first four groups equip them better for progress on land than is the case with the more completely marine forms. That this is actually so with the common banded sea-snake is true, for Taylor found many under rocks or in fissures of the cliffs on rocky islets of the Sulu Archipelago. Elsewhere they are known to climb the poles supporting houses built out over the water and slither into the fishermen's blankets at night, presumably for the sake of warmth. Fortunately this particular species has a gentle and inoffensive temperament. The black rings which encircle its body are almost as broad as the blue-gray interspaces; the head is largely black above except for a ∩-shaped yellow patch with arms extending back from the snout to behind the eyes.

There are many kinds of banded sea-snakes, and the fact that some move about at night must not be taken as proof that all members of the family are nocturnal. Undoubtedly many are, for numbers will be attracted to a light thrown into the sea at night. Dr. S. Kneeland spent all day fishing in Manila Harbor without getting bite and then, in intense darkness between 9 and 10 P.M., hooked a half-a-dozen sea-snakes in an hour, salt pork being the only bait used throughout! In Manila Bay as many as 100 sea-snakes may be taken in a single haul of a beach seine. The fishermen there are so accustomed to finding them in their nets, and toss them back into the sea

with their bare hands so fearlessly, that some observers have been led to suppose that sea-snakes are not dangerous.

Apparently much depends on the species, for it is true that the common banded sea-snake seems loath to make use of its fangs, possibly because, their eyes being adapted to underwater vision, these reptiles are temporarily dazzled when brought up to the full glare of a tropical day. Whatever the cause, sea-snakes are not to be handled with impunity, for Dr. Malcolm Smith, not only a medical man but an accomplished herpetologist and leading authority on the group, states that there is scarcely a fishing village along the coast of Siam that has not a tale to tell of fatalities from sea-snakes.

Nor is this surprising, for Smith's own experiments with the common banded sea-snake revealed that, weight for weight, its venom was twice as toxic as that of a cobra. This corroborates the conclusions of earlier workers with other species such as the *valakadyen*, which is the Sinhalese name for *Enhydrina*. Albert W. C. T. Herre, long resident in the Philippines, writes, "In most places one hears tales of deaths from the bites of sea-snakes." Kneeland's captives, which seem to have been parti-colored sea-snakes, "were very savage, snapping at anything within reach," but it must be remembered that they had just been hooked.

Deaths among Europeans, though not unknown, are exceedingly rare, and Smith is of the opinion that sea-snakes never attack bathers. On the other hand, he was told by a man with many years' experience of pearl-fishing on the north coast of Australia that his divers were frequently bitten but suffered little inconvenience beyond a temporary faintness and sickness. In this instance it was probably some species of the genus *Aipysurus* that was responsible, which again shows that much depends on the species both as regards the strength of its venom and its viciousness. As with land snakes, it is likely that the majority of sea-snakes are only too eager to escape when disturbed. Those species that enjoy basking on the surface of the ocean on calm days, are said to dive and disappear the moment they feel the vibration of an approaching steamer.

The primary purpose of the sea-snakes' venom is, of course, to

overcome the fish on which these reptiles subsist, and which they are admirably adapted to pursue under water. They are swift and accomplished swimmers, able not only to close their mouths completely but also to close the nostrils by means of a valve. Size of the prey would seem to be the sole criterion of edibility, for Annandale tells us that even strongly spinous fish are swallowed. The spines subsequently work their way out through the wall of the alimentary canal and skin, apparently without causing the reptile any serious inconvenience. Such a fish, about 3 inches in depth, was found in the stomach of a sea-snake taken by Robert Shelford off the coast of Borneo. But for its big meal, the snake could have escaped when the net was hauled into the boat, for its head and a considerable length of body were protruding through the mesh and Shelford was at first puzzled to know why the snake did not get away.

The more slender-bodied sea-snakes subsist on eels, and in this connection it is well to remember that certain tropical eels are highly poisonous, bite readily, and frequently have been mistaken for sea-snakes by bathers. Herre introduced an eel into a tank of sea-snakes at Manila, and as the eel swam past a Hardwicke's sea-snake the reptile bit it near the middle. The eel promptly straightened out, stiffened, and died almost immediately.

Outside of the tropics attempts to keep sea-snakes in aquaria have not been very successful; even in Manila very few of these reptiles survived captivity for more than eighteen months. Captive females have sometimes deposited eggs in the tanks, though normally they would have gone ashore to do so. It is only members of the small group of sea-snakes with broad belly shields that are oviparous; the majority give birth to live young, as is customary with aquatic snakes. Carl Semper states that female sea-snakes resort to the smaller islets in the Philippines to bring forth their young among the rocks. He found a score of young, each about 2 feet in length, with their mother, and therefore assumed that she remained with them for some time. The mother may have been about 5 feet long, but one species reaches 9 feet though the average length of these reptiles is about a yard.

Herre describes how even the most helpless kinds of sea-snakes con-

trive to come ashore by swimming into the water-filled crevices on a rising tide which deposits them upon the rocks as it recedes. During the breeding season, he says, one may see hundreds of these snakes on coral islets with vertical sides rising 10 feet or more above mean tide. At such times, Herre adds, the snakes are unusually active and inclined to be aggressive; walking is, therefore, dangerous for barefoot natives, who find it difficult not to step on the reptiles.

LAKE-DWELLING SEA-SNAKES

While the habitat of most sea-snakes is restricted to the oceans, a uniformly dark brown species known as Crocker's sea-snake lives in Lake Tungano on Rennell Island of the Solomon group. This lake, about 10 miles in length, is nearly 2 miles inland, and while not known to be connected with the sea its waters are too salty for the average palate, though local natives use it for drinking. On Luzon Island in the Philippines, Semper's sea-snake inhabits the fresh waters of Lake Bombon (sometimes miscalled Taal from the volcano of that name which rises from it), but the lake is connected by river with the not far-distant sea.

PARTI-COLORED SEA-SNAKE

In contrast to such restricted distribution we find the parti-colored sea-snake ranging from Madagascar through the Indian Ocean northwards to Siberia and across the Pacific to Panama and Mexico. No other sea-snake has anything like so wide a range, for the majority favor shallow seas and live off river deltas where there is likely to be an abundance of their finny food.

The parti-colored sea-snake, also known as the yellow-bellied or black-and-yellow sea-snake, is highly variable, for it may be black above and brown below with a stripe of yellow separating the two, or simply black above and yellow below, the two colors sharply distinct. Besides these variations there are half-a-dozen others, while the tail may be handsomely spotted or barred in many different ways.

The maximum length of the parti-colored sea-snake is just under a yard.

If this was the species which Kneeland hooked in Manila Bay, then his comment on the prehensile qualities of its tail is especially interesting. As he held the squirming reptile, its tail came in contact with, and closed about, the ring of a ship's lantern weighing some 15 pounds. Kneeland raised the snake, and the tail lifted the lantern clear of the deck; then he held it up till his arm was too weary to support the reptile and its burden any longer.

At Erabu-shima in the Luchu Islands one kind of sea-snake is so plentiful that it is widely known as *erabu-unagi*, after the locality from which quantities of them are shipped to Japan to be used as food. Herre tells us that Japanese fishermen from the Luchus, when visiting the Philippines, eagerly capture specimens of a yard or two in length, and any that are not eaten almost immediately are kept alive in earthen jars until required. It is no unusual sight, he says, to see a Japanese thrust his hand into a jar and pull out a huge snake with as little concern as if it were a length of rope. Possibly it was snakes of the same species which Malcolm Smith saw offered for sale in a Hainan fish market, where they were destined to be chopped up for sausage meat. It must be another species, however, that is commonly eaten by the Tahiti natives of the Society Islands.

Besides man, sea-snakes have other enemies in sharks and rapacious fish, to say nothing of birds of prey. Malcolm Smith tells of seeing a large buoy in the Bight of Bandon with the top literally covered with the remains of sea-snakes abandoned by birds which had devoured the softer parts. Birds must often carry a snake some distance before finding a suitable spot on which to eat it. This offers a possible explanation of how a sea-snake came to be found on Sumatra a day's march from the coast, for elsewhere a sea-eagle was seen to drop a snake some distance inland. The reptile was recovered and submitted to Malcolm Smith, who identified it as a viperine sea-snake.

Sea-snakes, unlike their terrestrial relatives, shed their scarf skin piecemeal, so it is not surprising to find their skins at times infested

with barnacles. Clusters of the crustaceans as much as an inch in diameter have been observed on the tail of a parti-colored sea-snake. To the extent that they impede the reptile's streamlining for swimming, such growths must be assumed to be disadvantageous. Whether this is offset by their presence rendering a resting snake less conspicuous to its enemies, or attracting small fish within range and so making it easier for the snake to seize them, is at present a matter for speculation.

9

Poisonous Land Snakes of the Viper Families

In describing the type of poison fang found in sea-snakes and elapids (p. 138), it was said to differ fundamentally from the fang of the vipers (VIPERIDÆ) and pit-vipers (CROTALIDÆ). Snakes of these families have hollow, tubular fangs (fig. 52) that are the very counterpart of a modern hypodermic syringe, for which they may well have been the model. Their smooth exterior shows no trace of a groove, but just above the point of the tooth is an opening through which the venom is injected into the wound made in striking. The venom gains admission to the tooth by an aperture at the front of the fang near its base. To discharge venom into this opening (described on p. 139) the duct has to turn back upon itself; should any venom be spilled in its passage from duct to hole, it will not be wasted for the duct opens into the fleshy sheath enveloping and protecting the fang, up which it slides in the act of biting (fig. 49).

The sheath moves up as the fang is raised; the mechanism by which this is accomplished is interesting. It has been made possible by the upper jawbone, to which the fang is attached, having become so shortened that it can be rotated by the upward pressure of another bone (the ectopterygoid), itself forced forward by muscles acting on a yet longer bone (the pterygoid).

As only two species of true vipers, as distinct from pit-vipers, occur in the Pacific region, their recognition presents no difficulties for their ranges do not overlap.

KEY TO THE SPECIES OF VIPER[1] OF THE PACIFIC

19 to 23 scales around middle of body; range: Sakhalin; Uisut; and Great Shantar Islands ..... common adder (*Vipera berus*)

27 to 33 scales around middle of body; range: Formosa; Java; and Endeh Island, Dutch East Indies ..... Russell's viper (*Vipera russelli*)

COMMON ADDER

The inclusion of the common adder, or European viper as it is often called, is on account of its abundance on the islands north of Japan. These adders from the extreme eastern part of their range have been separated under the name *sachalinensis* from those found in Wales and western Europe. The differences are slight, however, and the species occurs all the way from Scotland across northern Europe and Asia just south of the arctic circle at 70 degrees N.

On a sunny morning in these northern latitudes it is a delightful surprise to come upon one of these handsome little snakes quietly basking on a bank or at the base of a shrub. Few snakes are so readily recognizable, for from neck to tail-tip runs a conspicuous black zigzag line, while the crown of the head carries a V-shaped mark—"V for viper," say the children viewing it from the snout. The general coloring varies a good deal, females being usually some shade of olive-brown relieved by the black spotting on head and sides. The male, particularly after sloughing, appears resplendent in steely gray in sharp contrast to the black markings, but with age the gray dulls or darkens until the time for the next skin-shedding.

"Skin-shedding" is more descriptive than accurate, for it is not really the skin but the outer cuticle which a reptile discards. In this strange arrangement the new "ready-to-wear garment" is found beneath the old one. Sea-snakes slough piecemeal, but healthy land

[1] Ground-dwelling snakes having a pair of greatly enlarged, tubular, poison teeth that fold back when not in use on either side of the front of the upper jaw; *no deep depression* between nostril and eye.

snakes cast off their old epidermis entirely. As the time for shedding approaches, the snake becomes slightly blind owing to the loosening of the old cuticle over the watch-glass-like scale covering the eye; this often gives an opaque or bluish look to the eye.

The snake, which has probably been resting quietly for a day or two, now becomes restless, pushing its jaws against vegetation or other objects until the loosened skin of the lips turns back over the head and under the jaw. The snake continues on, as if it were crawling out of its old mouth as the discarded epidermis peels back, being reversed in the process as sometimes happens with a tight-fitting glove finger. Only the tail piece sometimes slips off without being reversed. Generally the slough is somewhat stretched in the process and longer than the snake that left it behind. The semi-transparent slough is a thing of beauty, and though uncolored, often reveals a certain amount of pattern pigmentation; an adder's, for example, shows the characteristic zigzag marking.

The common adder is usually from 18 to 22 inches long, but one of 33 inches has been recorded. The female, always larger than the male, gives birth to from five to twenty young. They are enveloped in a transparent membrane, which they rupture soon after birth. While young adders feed on lizards, the adults perform a useful role in keeping down the voles and field mice so destructive to crops. Adders are retiring and inoffensive, so that few people get bitten. When they do, the symptoms are likely to be painful and alarming, but subside within a few days, and deaths are rare from the bite of this species.

RUSSELL'S VIPER

It is a pity that one cannot say the same for Russell's viper, which unfortunately is considered as ranking third among the death-dealing snakes in India. There it is so abundant in some places that as many as 471 have been brought to one office for rewards in a single day.

Four-foot examples of Russell's viper are not uncommon; a 5½-foot specimen appears to be the largest known. This handsome snake is generally of a fawn or sandy shade, but varies considerably so that

local races, based chiefly on markings, have been described from Formosa, Endeh Island, and Java. The form found on Java has along its back a series of about twenty-four large, roundish, dark brown blotches encircled with black rings narrowly edged with yellowish white; on the tail the spots run together to make a stripe. Along each side is a series of similar, though smaller, blotches which alternate with those on the back. On the side of the flat and rather triangular-shaped head, a dark streak connects the eye with the lip. Below, this viper is whitish, more or less variegated with dark flecks towards the sides.

Dr. Frank Wall, who has written the best account of its habits, tells us that Russell's viper frequents open country but may be met with almost anywhere except in dense jungle. During the day it likes to bask in apparent lethargy, and at such times appears unwilling to strike unless provoked. Indeed, one would-be naturalist picked up a Russell's viper and carried it home under the impression that it was a young python. Only when it struck and killed his dog did the man awake to the fact that it was a poisonous snake he had been handling.

A thoroughly aroused Russell's viper will hurl itself at its tormentor with such vehemence that its tail may even leave the ground. The bite is usually a stab, followed by immediate release, but on occasion this viper will hold on so tenaciously that it has to be shaken off. The amount of venom necessary to kill a man has been estimated at about four-sevenths that normally delivered in a single bite. Even so, death need not follow from even an untreated bite. At least one case is known in which a man bitten by a Russell's viper showed no symptoms of poisoning whatsoever; possibly the snake's glands were empty.

It is as night falls that Russell's vipers become most active, and during the hours of darkness they enter houses or are found hunting their prey on roads and paths. This snake prefers small mammals but is not especially particular in regard to food. In the course of a year, one young Russell's viper in the Madras Museum ate four frogs, sixty-seven mice, two rats, and five squirrels. From this it will be seen that, unlike the common adder which does not stand captivity well, Russell's viper thrives; one in the London Zoo lived for more than five years.

The period of gestation is known to be in excess of six months, when as many as sixty-two or sixty-three young may be born at one time. These, however, are record families, and more normal broods range from thirty to forty. At birth the young measure from 8 to 11 inches and are well provided with venom, for mice succumb in a few seconds to the bite of a newly born Russell's viper.

PIT-VIPERS

The only family remaining to be considered is that of the CROTALIDÆ or pit-vipers, so called on account of the hollow depression between nostril and eye (fig. 48). It has long been known that this pit had a sensory function, but an understanding of its precise purpose is of relatively recent date. Only the outer portion of the cavity is visible, for a delicate membrane, stretched across the interior, conceals the deeper portion. Experiments have shown that this pit is extremely sensitive to minor changes of temperature, so that it informs the snake of the presence of even a small warm-blooded animal in the vicinity. In other words, it assists the viper when following up its stricken prey in the dark, to detect the motionless and possibly lifeless body of its victim lying nearby. Pits with a similar function are present on the lip scales of some of the Pacific pythons.

Best known of all pit-vipers are the rattlesnakes, but they are confined to the Americas, and in the Pacific region we find only relatives of the North American copperhead and the tropical American fer-de-lance. The two groups of genera may be separated as follows:

KEY TO THE GENERA OF PIT-VIPERS[1] OF THE PACIFIC[2]

Head covered above with a few large, paired shields; range: Japan east to Marshall Islands, southwest to Formosa; Sumatra; Java	ground pit-vipers (*Agkistrodon*)

[1] Arboreal or ground-dwelling snakes having a pair of greatly enlarged, tubular, poison teeth (that fold back when not in use) on either side of the front of the upper jaw; a deep depression between nostril and eye.

[2] Both occur on Asiatic mainland; *Agkistrodon* also in Europe and America.

Head covered above with numerous small scales; range: Luchus southwest to Sumatra, east to Celebes ..... climbing and also ground pit-vipers (*Trimeresurus*)

The three pit-vipers of the genus *Agkistrodon* found in the Pacific islands all agree in having the head broader than the neck, eyes with vertical pupils for night vision, usually twenty-one rows of scales around midbody, and a rather short tail.

KEY TO THE AGKISTRODON PIT-VIPERS OF THE PACIFIC [1]

1. Scales smooth; range: Sumatra; Java ..... Malayan pit-viper (*A. rhodostoma*)
   Scales ridged 2
2. Snout ending in a short, pointed, upturned appendage; range: Formosa ..... long-nosed pit-viper (*A. acutus*)
   Snout normal, not turned up; range: Japan and Luchus east to the Marshall Islands ..... Pallas' pit-viper (*A. halys*)

PALLAS' PIT-VIPER

Pallas' pit-viper, of which Blomhoff's viper is at most a local race, has a trans-Asiatic range from arid regions near the Ural Mountains of western Europe to Japan. The *mamushi*, as it is called in Japan, varies greatly, as might be expected of a reptile with so wide a range. It may be brownish, reddish, or even yellowish gray, with a series of large, oval, black-edged blotches on either side, their upper ends alternating along the middle line of the back. On each shield of the light brown head is an irregular darker marking, while a broad blackish streak, white-edged above and below, extends from the eye to the side of the neck.

Temperamentally, Pallas' pit-vipers are as variable as in coloration, for one author characterizes them as "extremely savage," while

[1] All three occur on Asiatic mainland.

Wall found captive specimens unwilling to strike. Nevertheless he thinks that dogs are not infrequently killed by Pallas' pit-vipers, though their bites are rarely fatal to man. When excited, they vibrate their tails as do many harmless snakes. A brood consists of from three to twelve young.

LONG-NOSED PIT-VIPER

The behavior of the long-nosed pit-vipers is also uncertain, for on Hainan Island John Whitehead found their disposition to be docile. Pope agrees with this, but adds that when sufficiently annoyed they will strike and bite "viciously." Wall goes further by repeating a rather improbable story of a Chinaman being "pursued" by a long-nosed pit-viper. While in general color this species shows some resemblance to Pallas' pit-viper, it differs sharply in the shape of the body markings, which are triangular, not oval. In adults the top of the head is uniformly black and the narrow black line from the eye to the corner of the mouth sharply separates the dark upper coloring from the white lips and underparts.

Full-grown 5-foot specimens are much darker than the young, though the pattern remains the same. Pope tells of recovering one young viper from the stomach of a nonpoisonous snake, while a rat and bird were disgorged by two of his long-nosed pit-vipers.

MALAYAN PIT-VIPER

The Malayan pit-viper, or *ular biludak* as it is called by some Javanese, is a rather handsome snake. Its head and back are gray, reddish, or light brown with a double series of darker brown angular markings arranged in pairs alternating along the back. From the eye to the corner of the mouth extends a broad, brown, black-edged streak, while the yellow or pinkish lips are speckled with brown. The underside of this pit-viper may be white or yellowish, with or without dark spotting.

Though the Malayan pit-viper is found on Java up to 5,000 feet on Mount Willis, it appears to be most abundant in wooded

country near the sea. It is generally regarded as having a sluggish disposition, unwilling to move out of one's way, yet ready to strike without provocation. Its bite causes considerable swelling and local pain which usually persists for several days. The females devotedly guard their eggs. These range in number from thirteen to thirty, according to Malcolm Smith. He found that the young of two broods took forty-two and forty-seven days to hatch from the time the eggs were laid, when well-developed embryos were already present. The little snakes are about 6 inches in length on hatching, and grow to 2 or 3 feet, according to sex.

TRIMERESURUS PIT-VIPERS

As will be seen from the following key, there are a score of different kinds of pit-vipers of the genus *Trimeresurus* on the Pacific islands that lie west of New Guinea. Though in most instances no one island will be found harboring more than two or three species, individuals of those species may be very plentiful. Most of them fall rather readily into one or other of two groups, (1) the dark-colored, ground-dwelling species with habits somewhat resembling those of the North American copperhead and moccasin, and (2) the greenish, only rarely brownish, climbing species with tails adapted to grasping firmly the twigs or branches on which the viper may be resting.

Their identification may not always prove easy, for some of these pit-vipers are known from less than half-a-dozen examples, so that much remains to be learned as to the range of variation within each species. Their distribution is, in a few instances, likely to be extended to other islands than those from which they have been recorded. I mention these matters in order that users of the key will not be surprised if their snake fails to fit completely within the limits assigned to every species as shown in the key.

KEY TO THE TRIMERESURUS PIT-VIPERS IN THE PACIFIC

1. Scales between the eyes smooth or faintly ridged; throat scales smooth 2

Scales between the eyes strongly ridged; throat scales ridged 20

2. Scales around midbody 33 to 37; belly shields 222 to 231; range: Luchus ..... yellow-green pit-viper (*T. flavoviridis*)

Scales around midbody 19 to 27; belly shields 127 to 218 3

3. Tail straight, not prehensile; [1] chiefly ground-dwellers 4

Tail prehensile, usually shown by its being strongly curled at tip, often slender, compressed and tapering; chiefly bush- or tree-dwellers 8

4. Belly shields 182 to 219; scales between eyebrow shields 10 to 16 5

Belly shields 127 to 176; scales between eyebrow shields 4 to 9 6

5. Belly shields 182 to 191; shields beneath tail 66 to 77; range: Luchus ..... elegant pit-viper (*T. elegans*)

Belly shields 198 to 219; shields beneath tail 76 to 96; range: Formosa [2] ..... pointed-scaled pit-viper (*T. mucrosquamatus*)

6. Angular ridge of head from eye to above nostril sharply angular; range: Luchus .... Okinawa pit-viper (*T. okinavensis*)

Angular ridge of head from eye to above nostril bluntly angular except in young 7

[1] See also the ashy pit-viper, with the tail prehensile in young but less noticeably so in adult snakes.

[2] Also Asiatic mainland.

7. Scales around midbody 21 to 27; shields beneath tail 36 to 62 in pairs or single; range: Formosa [1] ..... mountain pit-viper (*T. monticola*)

   Scales around midbody 19; shields beneath tail 19 to 31 pairs; range: Borneo ..... Chasen's pit-viper (*T. chaseni*)

8. First lower lip shield separated from its fellow by a pair of scales; angular ridge of head from eye to above nostril raised to form a parapet, upraised snout projecting in young; range: Borneo; Sumatra; Java [1] ..... ashy pit-viper (*T. puniceus*)

   First lower lip shield in contact with its fellow behind chin shield (fig. 38); angular ridge of head from eye to above nostril not noticeably raised 9

9. Scales around midbody 25 to 27; back dark purplish brown with or without pale green spots; range: Sumatra [1] ..... purple-spotted pit-viper (*T. purpureomaculatus*)

   Scales around midbody 19 to 21 10

10. Back dark purplish brown with or without yellowish spots, but without a yellow or white side stripe; range: Philippines (Polillo and Patnanongnan Islands) ..... Polillo pit-viper (*T. halieus*)

    Back greenish or yellowish (occasionally brown in old or large specimens) 11

11. Eyebrow shields large, separated across top of head by 4 to 9 scales 17

    Eyebrow shields narrow or broken up, separated across top of head by 8 to 13 scales .. 12

[1] Also Asiatic mainland.

12. Tail paler than body; belly shields 187 to 203; shields beneath tail 66 to 82; range: Philippines (Palawan Island) ..... Schultze's pit-viper (*T. schultzei*)

Tail colored like, or darker (rarely lighter) than body; belly shields 151 to 187; shields beneath tail 52 to 78 13

13. Color bright yellow with darker yellow streak on side (white in alcohol); end of tail spotted with reddish brown; range: Philippines (Bataan Island) ..... McGregor's pit-viper (*T. mcgregori*)

Color greenish (often bluish in alcohol) .. 14

14. Back spotted or barred with brown or uniform; side usually with a series of large yellow flecks on the lowest row of scales; range: Philippines (Luzon; Bohol; Mindanao; and Jolo Islands) ..... yellow-spotted pit-viper (*T. flavomaculatus*)

Back not spotted with brown; side with or without a narrow yellow or white line on the lowest row of scales 15

15. First upper lip shield partly or completely united with the nasal shield; upper lip and belly yellowish or greenish; range; Formosa; Hainan [1] ..... white-lipped pit-viper (*T. albolabris*)

First upper lip shield completely separated from the nasal shield by a suture 16

16. Hemipenis spinose (requires dissection; females are indistinguishable from next species); range: Formosa; Hainan [1] ..... Stejneger's pit-viper (*T. s. stejnegeri*)

[1] Also Asiatic mainland.

	Hemipenis without spines; range: (? Philippines); Borneo; Sumatra; east to Timor [1] .	Pope's pit-viper (*T. popeorum*)
17.	Belly shields less than 175 (162 to 174) .	18
	Belly shields more than 175 (177 to 198) .	19
18.	Belly shields 162; range: Djampea Island .	banded pit-viper (*T. fasciatus*)
	Belly shields 168 to 174; range: Borneo . .	Mt. Kinabalu pit-viper (*T. s. malcolmi*)
19.	Head shields and scales broadly edged with black; range: Borneo; Sumatra; Nias Island [1]	Sumatran pit-viper (*T. s. sumatranus*)
	Head shields and scales not edged with black; range: Banka; Sumatra; Nias Island	Hagen's pit-viper (*T. hageni*)
20.	Range: Philippines south to Sumatra Island east to Timor [1]	Wagler's pit-viper (*T. wagleri*)

YELLOW–GREEN PIT–VIPER

As to their venomous attributes, they range all the way from the greatly feared bite of the yellow-green pit-viper of the Luchus, where it shares the name *habu* with other vipers, to Wagler's pit-viper, whose inoffensive ways have resulted in its adoption as a temple pet. With so many species involved it will be possible to refer only to the habits of a few that are more or less representative of the others.

MOUNTAIN PIT–VIPER

The mountain pit-viper is well named for the distinct preference which it shows for mountainous country, where it has been taken

[1] Also Asiatic mainland.

as high as 7,000 feet. In China the males appear to be secretive in their habits, according to Pope, who has given a detailed account of the guarding of eggs by females of this species. In one instance the mother snake was found coiled upon her eggs in a mass of waste material derived from the shredding of bamboo, a by-product of Chinese paper-making activities. The half-dozen eggs found in mid-August were in a cavity about a foot below the surface of the pile, and the mother resolutely refused to desert her post until the eggs were removed. One of the eggs held a faintly pigmented embryo nearly 5 inches long, but it has been established that inch-long embryos are to be found in the eggs of the mountain pit-viper before they are deposited. The Kuatun eggs hatched out in September, each little snake being provided with what is known as an egg-tooth on its snout. With this temporary tool (for it is shed shortly after hatching), the little snake contrives to slit one end of the parchment-like shell, and so escapes from its prison. It is interesting to note that some species of snakes with young born alive also have an egg-tooth, seemingly a survival from earlier times when they hatched from eggs.

WHITE-LIPPED PIT-VIPERS

Apparently white-lipped pit-vipers occupy something of an intermediate position between the ground-dwelling forms like the mountain pit-viper and the tree-living members of the genus. For white-lipped pit-vipers are said to be as much at home on the ground as in a bush, in the grassy or bush-covered types of country where they live. Their food consists principally of rats, but lizards and frogs are also eaten. Pope, who collected many of these vipers in China, tells of taking up one which was hanging to the outside of a basket. The reptile made no attempt to bite, but later when it was restrained by having a stick placed on its back, it struck with lightning speed, and continued to do so each time the stick was moved near it. About seven young white-lipped pit-vipers are born at a time.

STEJNEGER'S PIT-VIPER

While the white-lipped pit-viper reaches a length of just over a yard, its smaller relative, Stejneger's pit-viper, is rarely as much as 2 feet long. Both agree in their green color, in having a narrow yellowish line along either flank, and in the tail-tip being pinkish. On Formosa, where they are common, it is likely that they are to be found at night hunting frogs in mountain torrents or among boulders and pools left in the river beds. It was in such situations in China that Pope encountered them, noting with surprise that the snake not only struck out readily, but lashed about with the hinder portion of its body in an unexpected manner. The number of young produced by a Stejneger's pit-viper is from three to five.

POPE'S PIT-VIPER

In a third species of this group, Pope's pit-viper, the light line along the side may be present or absent. All three species have long been confused with the smooth-scaled bamboo pit-viper (*gramineus*) of India, though in the three Pacific species the body scales are ridged. Known as the *ular bisa* in Sumatra and *esau* in Timor, Pope's pit-viper varies from bright green to olive above, green, yellow, or whitish below, with the tail-tip reddish or yellow. This yard-long, slender reptile has much the same varied diet as its close relatives, but apparently has larger families, the young numbering from seven to twelve at a birth.

WAGLER'S PIT-VIPER

Probably the commonest member of the group is the widespread Wagler's pit-viper, with a triangular head seeming even more distinct from the neck than are those of its relatives. Young Wagler's pit-vipers have a series of white or yellow spots arranged in pairs along the back. As the snake grows, the spots become vertical stripes or transverse bars bordered with red or black. Apparently the black

then develops at the expense of the lighter markings, for very old snakes, at least on some of the islands, show only broad black bars or crossbands at regular intervals along the body, which is usually vivid green with each scale edged with black; the tail is often marked with reddish brown.

Though a yard in length, the *ular puckuk*, as Wagler's pit-viper is called in Sumatra, is so slow in its movements and so little feared that the natives put it on trees near their homes to bring "good luck." On Penang Island many are kept in the famous Snake Temple.

While their food consists chiefly of lizards and birds, these climbing snakes also eat small mammals which they find when moving from one tree to another. Though their venom proves fatal to mice, Dr. Malcolm Smith's experiments led him to conclude that it was unlikely to cause death in man, or indeed in any animal over 50 pounds in weight. This corroborates the conclusions of field naturalists like Shelford, who remarks that during his residence in Sarawak he never heard of death resulting from the bite of a Wagler's pit-viper. In fact, despite this snake's formidable fangs, the few persons who were bitten apparently suffered little pain or inconvenience.

10

Snake Bite and First Aid Treatment

SNAKES and the tropics are associated ideas in many minds, with the result that some people, when southward-bound, actually worry over the possibility of being bitten. To such people it may be a consoling thought that venomous snakes are probably as abundant in certain southern states of the Union as in any part of the world, yet in the United States deaths from snake bite are less numerous than deaths from lightning. Incidentally, it is not the snake-catcher who runs a risk of being bitten so much as the bird-watcher or butterfly-hunter, whose eyes are on his quarry instead of on the ground.

PREVENTION OF SNAKE BITE

"Look where you are going," is certainly the first step in the prevention of snake bite, for between 60 and 90 per cent of bites occur below the knee. The second rule is not to go barefoot, particularly at night. When it is necessary to walk through rank grass or undergrowth, high boots or leather leggings are advisable. Personally I wear neither, for they are noisy and give warning of approach to the wild things which one likes to see. Spiral puttees worn with ordinary boots are better in this respect and provide reasonable protection. Slacks are good, for when hanging free of the leg they cause a snake to misjudge its stroke, so that the fangs hit the trousers instead of the limb itself. Moreover, in cases where the fangs are non-tubular, even if they should reach the flesh, there is a good chance of some of the venom being absorbed by the material, be it trousers cloth or puttee.

In numerical importance according to statistics, bites on the hand or arm are second only to bites on the foot. The majority of these

bites occur when workers cleaning a plantation take up an armful of rubbish in which a snake is concealed; or when berry-gatherers or flower-pickers thrust a hand close to a basking snake; or when a rock-climber reaches up to grasp a ledge where a snake is sunning. Nor, when walking along a narrow jungle trail, is it wise to let your hand and arm brush against the bordering vegetation.

To sleep on the ground is to invite trouble, particularly in regions where the days are hot but the nights cold. A wandering snake—and many of the venomous species are nocturnal—encountering blankets is likely to insinuate itself among them for the sake of welcome warmth. I caught a cobra that, on successive nights, had chosen to lie beneath a corporal's duffle-bag pillow, and was found there when he arose in the morning. The idea that a bristling horse-hair rope encircling the sleeping place affords protection is probably fallacious, for it is difficult to imagine a sizable snake being deterred by such an obstacle. A camp-bed with mosquito-curtain well tucked in allows one to sleep in confident security.

If a broad belt around camp is thoroughly cleared of vegetation, snakes are more likely to be seen and killed before they reach the living quarters. Attempts to achieve large-scale protection by offering bounties calculated to result in reduction of the snake population, have not proved very effective. This is due to the operation of a biological law that results in the increase in size of families when there is an abundance of food. Thus nature's efforts to maintain a balanced population counteract attempts at extermination by offering a bounty, unless the latter is accompanied by changes in the snake's food supply or other factors.

RESULTS OF SNAKE BITE

Suppose that, despite precautions, a person has had the misfortune to be bitten by a snake. It is important to know whether the reptile was a harmless or poisonous species (p. 138), and if poisonous, to which of the four families of venomous snakes it belongs, for this has a distinct bearing on treatment.

Generally speaking, the venom of cobras and sea-snakes acts on

the nervous system (neurotoxic), the venom of vipers and pit-vipers upon the blood (hemolytic). As all venoms are complex, containing both these and other properties in varying proportions, there are several exceptions to this generalization. The diverse effects of *fatal* bites from snakes of these two types are best shown by the following accounts.

The bite of even a large cobra is not very painful, according to Albert Calmette, who says that it is characterized by numbness in the bitten part. The numbness rapidly extends throughout the body, producing syncope and fainting. Soon the patient is overcome with lassitude and an irresistible desire to sleep; his legs will scarcely support him, and breathing becomes labored. As the drowsiness and difficulties of respiration increase, the pulse, which at first was more rapid, becomes slower and weaker; "the mouth contracts and there is profuse salivation; the tongue appears swollen; the eyelids remain drooping; and after a few hiccoughs frequently accompanied by vomiting and involuntary emissions of urine or fecal matter, the unfortunate victim falls into the most profound coma and dies. The pupils react to luminous impressions up to the last moment, and the heart continues to beat sometimes for two hours after respiration has ceased." This takes but a few hours, usually from two to seven. Sir Joseph Fayrer found that of those who succumbed to the bite of the Indian cobra, 23 per cent died within two hours, and only 21 per cent lived for more than twenty-four. Victims of the king cobra often die within the hour.

Contrast this elapid poisoning with the effects of a bite from a large pit-viper. Immediately after the stroke there is fiery pain at the site, owing to the action of the venom on the nerves. This is quickly followed by profuse bleeding, as red and then purple discoloration spreads as a result of anti-coagulative action. Rapid swelling sets in as cell-destroying (cytolytic) elements attack the walls of the smaller blood vessels and the blood, damaged by blood-poison (hemorrhagin), seeps through to infiltrate the tissues. Sharp pains travel up the limb, sometimes accompanied by cramps. The delicate membranes of the eyes and mouth become congested; the patient may complain of intense thirst and at times become more or

less delirious. Nausea and vomiting are produced by nerve-poisons (neurotoxins). The pulse is rapid, sometimes double the normal rate, owing to the low blood pressure. These symptoms may continue for a day or two and be accompanied by hemorrhage from the eyes, mouth, stomach, intestines, or bladder. Presuming that a lethal dose of venom was administered, the victim gradually relapses into stupor and insensibility followed by somnolence. Respiration becomes increasingly difficult and breathing stertorous till asphyxia ensues, the heart continuing to beat for almost fifteen minutes after respiratory movements have entirely ceased.

Of course, in exceptional cases when the snake's fang penetrates a vein, death may supervene so suddenly that distressing symptoms have no time to develop. Certain viperine venoms may produce such rapid coagulation of the blood as to induce generalized clotting. Normally, however, death from a viper bite is slower than from the bite of cobra or coral-snake. It should be added that persons who recover from pit-viper bites—and even among the untreated or poorly treated about 85 per cent are said to do so in the United States—are sometimes subject to recurrent sloughing or suppuration extending over many months. In Australia, where there are no vipers, all the venomous snakes are of the elapid type, yet the annual death-rate from snake bite is only about twelve persons out of a population of 6,500,000.

FACTORS FAVORING RECOVERY

From this it will be seen that it is a fundamental error to assume that because a certain species of snake is *capable of* delivering a multilethal dose, a victim of its bite will die. The glands of the common cobra are said to contain fifteen minimum lethal doses of venom, yet statistics show that without any specific treatment there is a recovery rate of 40 per cent of those bitten. For such a state of affairs many factors are responsible; among them I might mention the following:

1. Snake miscalculating distance, and so striking a glancing blow.
2. An imperfect strike on account of withdrawing movement by victim.

3. Strike made through clothing resulting in absorption of some venom.
4. Strike delivered on lean region like shin with little tissue.
5. Strike delivered on very fat region resulting in slow absorption.
6. Exhaustion of venom resulting from snake having fed recently.
7. Reduction in amount of venom due to æstivation or hibernation.
8. Snake very young or old, affecting quantity of venom available.

Assuming that someone has been so unfortunate as to be bitten, the treatment to be adopted falls naturally under two heads: first-aid measures and specific or antivenin treatment.

Several excellent first-aid kits have been placed on the market in recent years. The one which I happen to take with me when snake-hunting is "B–D Snake Bite Outfit No. 2006," which is put out by Becton, Dickinson & Co., Rutherford, New Jersey. Except that it lacks the small-gauge rubber tubing for finger or toe, and permanganate, it contains all the paraphernalia necessary for steps 1 to 8 listed below. The deviser of the outfit, in correctly assuming that a bitten person may be agitated, has arranged that a turn of the wrist will remove the cap from either end of the little can containing the outfit.

FIRST–AID MEASURES

The first thing to do is to try to retard absorption of the venom into the general circulation.

1. Apply RUBBER LIGATURE *above* knee or elbow of bitten limb, tight enough to obstruct the superficial but not the deeper circulation. (As general absorption is exceedingly rapid, this should be done within a minute. For viper venoms with clotting properties, ligature is especially useful; it is less effective in the case of cobra or sea-snake bites, for their venom is largely non-coagulating. In absence of a rubber ligature, use a shoestring, handkerchief, or anything suitable.)
2. If bite is on finger or toe, apply a second RUBBER LIGATURE around the digit.

3. WASH venom off skin, preferably with a solution of PERMANGANATE OF POTASH.
4. If site of bite is hairy, SHAVE with RAZOR.
5. PAINT site of bite with IODINE solution.
6. If COBRA bite, CUT ¼ inch deep by ¼ inch long. If VIPER bite, CUT to bottom of punctures, remembering that the long fangs are recurved. (Transverse cuts should be made only when there is no risk of injuring a blood vessel, nerve, or tendon. The Red Cross advocates cross cuts ½ inch by ½ inch for pit-viper bites.)
7. As venom in a test-tube is oxidized and rendered inert by a 1 per cent solution of permanganate of potash, I should POUR a 1 per cent solution of PERMANGANATE OF POTASH into wound. (Some object to its use on the ground that it cannot overtake the venom already absorbed, and that if sufficiently strong to accomplish any good it is strong enough to cause injury to the tissues.)
8. Now deflate SUCTION BULB and APPLY FUNNEL to wound. (In absence of funnel, suck with mouth if latter is quite free of sores; spit out frequently.) Remove after a few moments and repeat continually for an hour, or up to three or four hours. Should blood refuse to flow, LOOSEN LIGATURE very slightly to increase bleeding. After a viper bite, the limb will swell in a few hours at most and bleeding become easier. (The Red Cross advocates encircling limb, where swelling is greatest, with cuts measuring ¼ by ¼ by ¼ inch and then applying suction to them for fifteen minutes per hour over a period of fifteen hours.)
9. Do not leave LIGATURE on for more than ten to twenty minutes before loosening for a minute, then tighten for five minutes, loosen for a minute, repeating process every five minutes. Move ligature up limb as latter swells. Some suggest IMMERSING the wound in a bright crimson solution of PERMANGANATE OF POTASH.
10. Get patient to bed and keep warm. SEND for a DOCTOR. He will probably administer the appropriate antivenin if it is

available. If no doctor can be reached, some of the following notes may prove useful.

11. To delay absorption of venom, aim at ABSOLUTE REST; make patient LIE DOWN.
12. Let him drink quantities of WATER. Give liquids only, such as half-hourly drinks of hot milk, cocoa, tea, coffee, soup, or eggnog. AVOID ALCOHOL.
13. Occasional SALINE MOUTH WASH may afford comfort. Administer EPSOM SALTS if necessary.
14. Symptoms of VIPER poisoning are those of shock. COMBAT coldness, weakness, collapse, rapid thin pulse, with warm wraps and hot-water bottles.
15. Inject MORPHINE SULPHATE for ADULTS if pain is intense, PAREGORIC for CHILDREN.
16. If restless, the bitten LIMB should be kept still on a SPLINT.
17. When acute stage is passed, a CYANIDE GAUZE DRESSING should cover the wounds and a mildly ANTISEPTIC PAD be applied firmly. (Red Cross advocates covering cuts, between suction periods, with hot compresses of EPSOM SALTS.)
18. ENZYMOL, used with equal parts of water, by digesting dead tissue, will assist in keeping the wounds healthy.
19. WOUNDS that turn SEPTIC may be treated with HOT FOMENTATIONS (warm ones only facilitate sepsis).
20. PEROXIDE OF HYDROGEN can be used to cleanse SEPTIC WOUNDS.
21. In some cases of COBRA bite, BLEEDING may be EXCESSIVE. Colonel Frank Wall suggests combating this with a deep intramuscular INJECTION of from two to three grains of CALCIUM, with the object of restoring calcium to the walls of the blood vessels. Superficial injection will damage tissues (necrosis); larger injections are likely to induce clotting of blood (thrombosis).
22. Take blood specimen and have it typed and matched in preparation for a TRANSFUSION, one or more of which may mean the saving of a life. Obtain a suitable BLOOD DONOR.

The first-aid portion of the foregoing treatment, sometimes referred to as the cut-and-suck method, has been advocated strongly by Dr. Dudley Jackson of San Antonio, Texas. Dr. Jackson demonstrated that dogs might be killed by an injection of the bloody fluid drawn off by the suction cup from a bitten dog, while the bitten dog itself recovered. Even fluids drawn from around the site of the bite of a man bitten fourteen hours previously, caused serious poisoning when injected into a dog. The statement that "suction can never remove the poison injected by the snake's fangs" has been disproved repeatedly.

SPECIFIC OR ANTIVENIN TREATMENT

It has long been known that certain natives built up an immunity to snake venom by allowing themselves to be bitten by young poisonous snakes and gradually increasing the dosage. Dr. Calmette said that in six months he could immunize a rabbit to the point where it could withstand 100 lethal doses, and a horse until it would take enough venom to kill eighty horses. Serum treatment is based on the transference of this immunity from a horse to a bitten person.

At first the distinctive nature of venoms was not fully appreciated, and claims were made that processed serum derived from a horse immunized only against cobra venom would be efficacious against the bite of any poisonous snake. When the fallacy of this claim was realized, specific serums for certain snakes were put on the market. This was soon followed by various mixed antivenins prepared from the serum of horses immunized against two or three types of venomous snake found in a particular region. This antivenin was available for use in that particular region when the species of snake which had inflicted the bite was not definitely known. It is probable that specific antivenins are not available in many parts of the Pacific at the present time. In the case of severe poisoning by a North American pit-viper, Dr. Dudley Jackson advocates the use of from five to fifteen ampules of the appropriate antivenin.

11

Economic Aspects of Reptiles and Need for Protection

DESPITE the relative rarity of deaths from snake bite, some people loudly demand that the whole serpent tribe be exterminated. They overlook the role snake venoms have been playing in recent years, for which their diverse characteristics make them particularly suitable. Thus we find cobra venom being employed to alleviate the severe pain accompanying certain malignant tumors, for it has the advantage of not being habit-forming. Hemophilia, that inherited disease of excessive bleeding from minor wounds, is being treated with the venom of Russell's viper, for it is rich in coagulating properties. Pit-viper venom is also used to control hemorrhages, and some kinds have proved useful in a few types of epilepsy.

SNAKES AS AN AGRICULTURAL ASSET

But it is not on such slender grounds that naturalists counsel caution in complying with demands for wholesale destruction of snakes. Local conditions should be taken into account, for in many sparsely-settled agricultural districts the main bulwark against rodent plagues may be the venomous snakes which principally prey on rats and mice. Whatever views may be entertained as regards venomous species, there should be no question about extending protection to the harmless rodent-eating reptiles with a sinuous shape admirably adapted to entering rat-holes and killing the young.

Our information regarding the usefulness of Pacific snakes is scanty at present, but Clifford H. Pope cites ample evidence of the

cash value to farmers of many North American species. One reptile killed in Utah held thirty-five field mice; of another kind it was calculated that each adult accounted for a dozen pocket gophers every summer. One has only to assess the damage done each season by mouse or gopher in granary and alfalfa field to gain an idea of the service performed by thousands of rodent-eating reptiles.

It is, of course, true that these benefits are offset by the eating of an occasional bird, its nestlings, or some useful insectivorous frogs and toads. If usefulness is to be the sole criterion, it will be some task to evaluate each species on its merits. There are snakes that will be found to subsist almost exclusively on slugs and snails, the burrowing blind-snakes on termites. Enough has been said to show how foolish it is to slay every snake on sight without regard to the part it is playing in the economy of nature.

TRADE IN SKINS

The existence of large snakes in the Orient is already being threatened by the trade in their tanned hides. For this any snake is eligible with a striped skin 8 inches in width, so in 1931 we read that more than 1,500,000 snake skins were exported from the Dutch East Indies alone. Once commerce becomes seriously interested in any creature, the days of that species are numbered unless restrictions are enforced to prevent its extinction. Unfortunately, nonpoisonous species like the beautiful reticulated python and the ugly wart snake are chiefly menaced by the skin trade which sprang up twenty years ago.

The popularity of reptile skins is due to certain advantages that they possess, excelling those of goat or calf. Though their natural coloration disappears soon after death or during tanning, they can be finished in any color. Not merely do they offer considerable variety in pattern and texture, but they wear better. So we get python-skin gloves and snake- or lizard-skin belts, purses, and shoes.

The lizards that chiefly contribute to the novelty trade are monitors. Their skins are carefully graded by the trade according to

whether their granulation is fine or coarse, whether the granules are smooth or ridged, and other factors. The price they command is ruled by the quality, and trade names are applied to each different type. Malcolm Smith says that during September 1932, 600,000 lizard skins, chiefly monitor, were shipped from Calcutta alone. In the Dutch East Indies steps have been taken to protect the giant Komodo monitor. It would be a tragedy indeed if this largest of all living lizards were to be exterminated on its island home.

I do not know to what extent crocodile skins are being sought on the islands, but Dr. Deraniyagala tells us that before hide-hunting began in Ceylon over 100 marsh crocodiles might be seen basking together. In those days 9-foot specimens were common, but now it is unusual to see individuals over 6 feet in length. Generally speaking, crocodiles could do with some reduction, and survivors are likely to be able to take care of themselves. Few people would shed a tear if the man-eating estuarine crocodiles were exterminated throughout the greater part of their vast range.

SHEEP ENDANGER TUATARA

An even greater catastrophe than the extinction of the giant monitor would be the death of the last tuatara. That quaint survivor of an entire order of reptiles had lived on New Zealand down through the centuries until pigs and other animals, introduced by Captain Cook, killed them off. Today the Government-protected remnants are to be found on only a few rocky islands. There, says Dr. F. C. Blanchard, the lighthouse-keepers' sheep are steadily reducing the bushes that harbor the insects on which the tuatara depends for food.

MONGOOSES A MENACE

The existence of some insular reptiles has been endangered by the introduction of rats, and subsequently of mongooses to keep down the rats. Mongooses, being omnivorous animals, refuse to confine their diet to one particular item and devour both eggs and young of

many reptiles. This seems to be the situation affecting the banded iguana on the Fijis. It is also probable that natives hunt it for food, for the flesh of some of its mainland relatives tastes like chicken and is much sought after.

Even the seaweed-eating marine iguanas of the Galápagos are edible, for back in 1813 Lieutenant J. Shilliber of H.M.S. "Briton," wrote: "Guanas we found here in great abundance, and notwithstanding their disgusting appearance, they were eaten by many of the sailors, who esteemed them as most delicious food." Sometimes the land iguanas of the Galápagos are killed for food too, but their chief danger lies in the value of their hides as leather. A few years ago it was reported that the Ecuadorian Government had granted concessions for their exploitation.

DESTRUCTION BY DOGS

In the interests of succeeding generations, the conservation of the unique Galápagos fauna should receive prompt attention. Legislative enactments are quite inadequate; an active campaign against the imported dogs, cats, and rats is imperative. Already the giant tortoises peculiar to the archipelago have been exterminated on some of the islands. As previously stated, this was primarily due to their being carried off by whalers to furnish their crews with fresh meat. Dr. C. H. Townsend estimated that 10,000 were taken in this way between the years 1831 and 1868. Worse still, the visiting ships left rats and dogs behind them. The former preyed on the young tortoises; the latter attacked both young and old. In the present century commercial hunters ruthlessly slaughtered hundreds of the tortoises for the sake of their oil, so that with each succeeding year the prospect for their survival appears less promising.

MARINE TURTLES

Their oil, their flesh, or their "shell" are the three reasons for which one or other of the big sea turtles is harassed by man. On

some islands even the wholesale collection of turtle eggs has assumed the proportions of a major industry. The responsible governments, realizing the importance of the trade, have in most instances taken steps to safeguard its future, so that it is now improbable that any of the marine turtles, though greatly reduced in numbers, is likely to suffer extinction.

Some of the freshwater species, like the soft-shelled turtles of Japan, are already being farmed. It may be that this is the solution which will ensure the preservation of certain other kinds which, like the diamond-back terrapin in this country, are amenable to cultivation in captivity.

PURPOSE OF COLLECTING

At first sight it may appear anomalous that those most active in pointing out the dangers of commercial exploitation and in urging conservation, have generally been naturalists—often themselves collectors. This is not so surprising when one realizes that it is the students of wild life who best appreciate the dangers of destroying some useful creature. While such men also deplore wanton destruction of the type where some harmless reptile is used as a target on which to test a rifle, they recognize that our knowledge of reptiles is increased by collecting them when this is carried out intelligently and with moderation.

12

A Brief Survey of the Pacific Amphibians

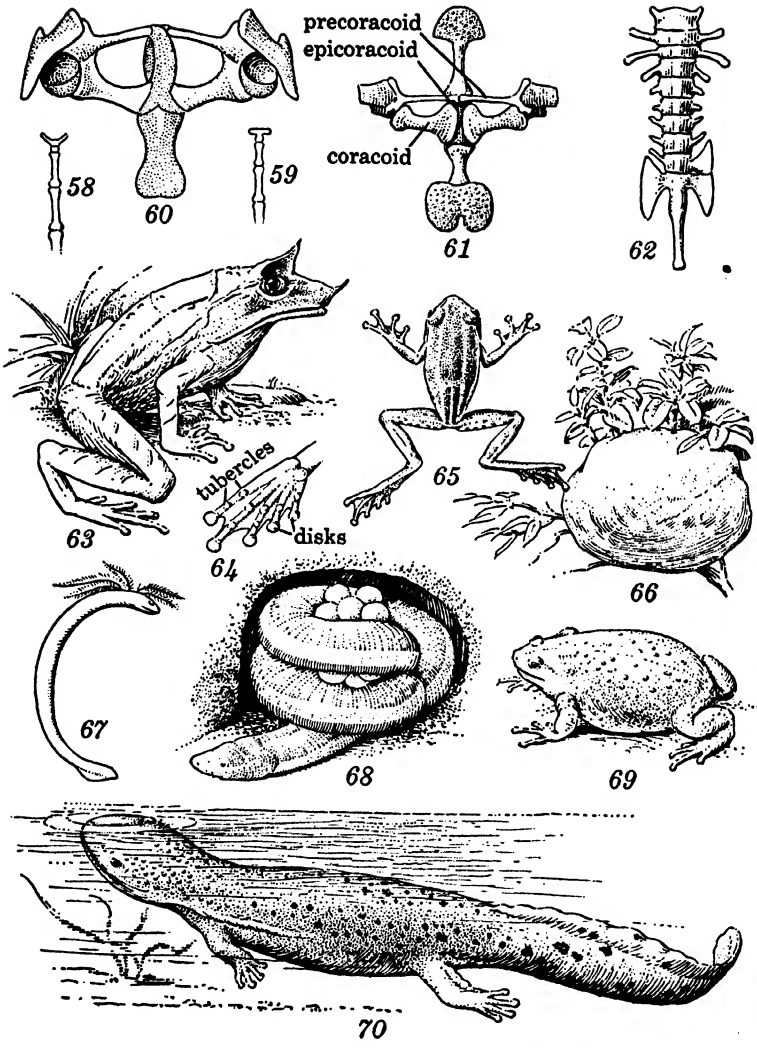
WHATEVER differences of opinion there may be as to the desirability of according protection to all snakes, there can be no question about the wisdom of safeguarding the amphibians, especially the toads and frogs, whose services to mankind are incalculable. Without their assistance in destroying the superabundant insects of the tropics, agriculture would be much more difficult, and life itself more unpleasant.

To a naturalist it may seem incredible that anyone could mistake an amphibian for a snake or lizard. Nor is there any excuse for doing so if we remember that reptiles are clothed in scales or shields. Amphibians are not, unless we choose to include the almost microscopic scales which are embedded in the soft skin of some cæcilians. Other distinguishing characteristics have been dealt with already (p. 7), so there is no reason to repeat them here.

In the tropics toads and frogs are more often heard than seen, for the majority conceal themselves in some congenially cool and damp spot by day. At night they venture out, for then there is no fierce sunshine to shrivel their tender moist skins, which are so essential an aid to respiration. The roughened and warty skins of toads are less affected, and a few frogs, like the water-storing species found in desert areas of central Australia, have developed adaptations to counteract such adverse conditions.

All living members of the class AMPHIBIA fall into one or other of three distinct orders mentioned in the following key to the families. In this key the word *adults* is used to avoid complications arising from the inclusion of frog tadpoles (pollywogs) or the larval forms of salamanders.

PLATE VII


precoracoid
epicoracoid
coracoid
58
59
60
61
62
63
tubercles
disks
64
65
66
67
68
69
70

KEY TO THE FAMILIES OF THE AMPHIBIA OF THE PACIFIC [1]

1. Adults without limbs; body worm-like or snake-like (fig. 68); order APODA; range: Philippines southwest to Sumatra and Java ..... cæcilians (CÆCILIIDÆ)

   Adults with limbs; body neither worm-like nor snake-like 2

[1] Ranges outside the Pacific not included. The family definitions employed do not necessarily hold outside the Pacific. Unfortunately dissection is necessary to settle alternatives in "8" which separates two parallel groups of families.

PLATE VII

FIG.

58. Finger bones of a rhacophorid tree-frog (*Rhacophorus*) showing cartilaginous pad between last and last-but-one bones.
59. Finger bones of an ordinary frog (*Rana*) showing absence of cartilaginous pad.
60. Breast skeleton of a toad (*Bufo*) showing coracoid and precoracoid bones connected by overlapping epicoracoid cartilages.
61. Breast skeleton of a frog (*Rana*) showing coracoids firmly united by a simple epicoracoid cartilage.
62. Vertebral column of frog (*Megophrys*) showing absence of ribs.
63. Nose-horned frog (*Megophrys nasuta*) which lacks subarticular tubercles under its fingers and toes.
64. Hind foot of a rhacophorid tree-frog (*Rhacophorus*) showing tubercles under articulations (joints) and terminal disks.
65. A rhacophorid tree-frog of Japan, one of a group which closely resembles the hylid tree-frogs.
66. Rhacophorid tree-frog's froth "nest" placed in a shrub overhanging water.
67. Embryo (much enlarged) of sticky cæcilian removed from egg to show gills which disappear before the hatchling takes to water (after Sarasin).
68. Sticky cæcilian coiled about her eggs in burrow on banks of ditch or stream (after Sarasin).
69. Narrow-mouthed frog (*Kaloula baleata*) as representative of a large family, many of whose members are burrowers.
70. Giant salamander of Japan, largest of all amphibians, for it sometimes reaches a length of 5 feet.

2. Adults with a tail; body lizard-like (fig. 70); order CAUDATA 3

   Adults without a tail; body frog-like (fig. 65); order SALIENTIA 5

3. No eyelids; size huge; range: Japan — giant salamander (CRYPTOBRANCHIDÆ)

   Eyelids well developed; size small .. 4

4. A series of vertical grooves along flanks; teeth on roof of mouth forming a wavy transverse series or, if extending backward on palate, posteriorly converging; range: Japan south to Formosa .... — Oriental-salamanders (HYNOBIIDÆ)

   No vertical grooves along flanks; teeth on roof of mouth extending backward on palate as 2 parallel or posteriorly diverging series; range: Japan south to Luchus ..... — salamanders and newts (SALAMANDRIDÆ)

5. Digits without subarticular tubercles 6

   Digits with subarticular tubercles (fig. 64) 8

6. Tongue adhering to floor of mouth; range: Quelpart Island and Tsushima off Japan, also Busuanga Island, Philippines ..... — disk-tongued frogs (DISCOGLOSSIDÆ)

   Tongue slightly free behind 7

7. Short ribs attached to the foremost transverse processes of the vertebræ which are slightly dilated; range: New Zealand ..... — tail-muscled frogs (ASCAPHIDÆ)

No ribs; transverse processes of the vertebræ strongly dilated (fig. 62); range: Philippines south to Sumatra east to Java ..... toad-frogs (PELOBATIDÆ)

8. Coracoids and precoracoids connected by an arched cartilage (the epicoracoid), that of the one side overlapping the other (fig. 60) 9

Coracoids firmly united by a simple epicoracoid cartilage; precoracoids, if present, each resting with its distal extremity upon the coracoid, or connected with the latter by the epicoracoid cartilage (fig. 61) 11

9. No teeth in upper jaw or on roof of mouth; range: Sakhalin south to Dutch East Indies[1] ..... true toads (BUFONIDÆ)

Teeth present in upper jaw and usually present on forward part of roof of mouth 10

10. Tips of fingers and toes not dilated into disks; ground-dwelling or in water; range: New Guinea ..... southern-frogs (LEPTODACTYLIDÆ)

Tips of fingers and toes dilated into disks; chiefly bush or tree-dwelling when not in water for breeding; range: Japan southwest to Sumatra, east through New Guinea to the Solomons[2] ..... tree-frogs (HYLIDÆ)

[1] Introduced into Solomons, Marianas and Hawaiian Islands.
[2] Introduced into New Caledonia and New Zealand.

11. Teeth present in upper jaw and usually present on forward part of roof of mouth 12

    No teeth in upper jaw or on roof of mouth (except in 2 rare Bornean species, and rudimentary in 1 New Guinean frog) 13

12. Tips of fingers and toes dilated into disks; a cartilaginous pad between the last and last-but-one finger bones (fig. 58); range: Japan southwest to Sumatra, east to Celebes ..... rhacophorid tree-frogs (RHACOPHORIDÆ)

    Tips of fingers and toes undilated or dilated; if dilated then there is often (but not always) a groove around the disks; no cartilaginous pad between the last and last-but-one finger bones (fig. 59); range: Sakhalin Island southwest to Dutch East Indies, east through New Guinea to the Solomons ordinary frogs (RANIDÆ)

13. When hind leg is brought forward, the heel does not reach beyond end of snout; skin usually smooth; no raised glandular fold from behind eye to above forearm; (about 90 species); range: Quelpart Island southwest to Sumatra, east to New Guinea ..... narrow-mouthed frogs (BREVICIPITIDÆ)

    When hind leg is brought forward, the heel reaches far beyond end of snout; skin rough and warty; a raised glandular fold from behind eye to above forearm; (1 species); range: Borneo and Sumatra ..... glandular frogs and toads (ATELOPODIDÆ)

STICKY CÆCILIAN

Of the three kinds of limbless amphibians inhabiting the Malayan subregion, the commonest appears to be the sticky cæcilian which besides being found in Borneo, Java, and Sumatra, has an extensive mainland range from Indochina to India and Ceylon. Because of the burrowing habits of these harmless, worm-like creatures, they are seldom seen except during the rainy seasons. Then they are not infrequently killed on roads and paths, being mistaken for burrowing snakes, to which they show some slight resemblance in their toothed jaws and beady black eyes. Each eye is encircled by a pale ring which is in contrast to the general bluish black or dark brown coloring, that of the back being separated from the dark belly by a sharply defined, if narrow, bright lemon-yellow band along either side.

The sticky cæcilian burrows in the soft soil bordering streams, an environment connected with its strange life history. For there the gravid cæcilian, having selected a patch of suitably moist soil near the surface of the ground, moves around until she has formed a cavity in which to lay her eggs. These may number a score or more, and each yellow egg measures about ¼ inch in diameter. The eggs, being strung together by twisted cords of albuminous membrane, form a compact bunch. Around this bunch the mother coils (fig. 68) to protect it from enemies or possibly to conserve the moisture during the period of development. Within the egg the developing embryo breathes by means of extraordinarily long and finely fringed gills, of which there are three pairs (fig. 67).

As the embryo develops, the egg increases to twice its original size, while the larva upon hatching weighs four times as much as the egg when first laid. Shortly before hatching, the gills shrivel up and disappear, leaving only tiny holes, one on either side of the neck, in the gill-less hatchling. Already the eyes of the little creature are well developed, but the strangest thing about it is that its short tail carries a distinct fin both above and below. As to the purpose of this fin, we are not left long in doubt, for the larval cæcilian takes to the water

where it lives an eel-like existence until it reaches a length of from 3 to 6 inches.

As the time arrives for the fish-like larva to forsake the water, its tail fins disappear, the gill-clefts close, and a tentacle develops just in front of and below each eye, which is protected by a film of skin. The skin itself undergoes striking changes and displays grooves along its entire length from head to tail. With this fresh equipment the young cæcilian leaves the stream to burrow in the bank like a worm, and if returned to the water will drown as readily as a worm. Unlike most earthworms, however, in the matter of diet cæcilians are carnivorous; they subsist chiefly on termites ("white ants") but even swallow an occasional worm if they should happen to meet.

WEBER'S AND UNIFORM CÆCILIAN

To assist in mastering its prey, the sticky cæcilian is furnished with both an outer and an inner series of teeth in the lower jaw. In this respect it differs from the uniform cæcilian whose inner row is represented by a very few teeth, while in Weber's cæcilian of the Philippines the inner row has disappeared entirely. Both these species lack the conspicuous yellow side stripe of the sticky cæcilian.

GIANT SALAMANDER

The Japanese giant salamander has the distinction of being both the biggest and the longest-lived amphibian in the world, surpassing even its North American relative the hellbender. A giant salamander that lived in the Leipzig Zoo weighed between 88 and 99 pounds at the time of its death. The maximum length of 5 feet is recorded for an example of the race found on the Chinese mainland.

On the islands, the Japanese form appears to inhabit only the swift mountain streams of Hondo Island at altitudes above 1,300 and below 3,000 feet. There, lurking in the deeply shaded sections, this repulsive-looking giant leads a somewhat solitary life, feeding on any amphibians, fish, worms, or insects that come within its reach. In

order to seize large prey, the great jaws of the massive, warty head have a wide gape. On the stout body the skin is smoother, slimy, and often wrinkled along either flank; the sturdy limbs have four and five toes respectively on front and hind feet. The tail is shorter than the head and body, is compressed, and carries a fin, for this is a wholly aquatic amphibian.

An egg of this giant salamander measures about ½ inch in diameter. It is composed of several layers of transparent jelly surrounding the ¼ inch sphere of yellow yolk. The eggs, strung together in much the same fashion as those of the sticky cæcilian, form clumps of from seventy to eighty. These, to a total of about 500 eggs, are deposited in a deep hole in the river bed. Fertilization takes place as, or after, the eggs are laid, whereupon the male salamander assumes the tasks of nurse and guardian. From time to time he noses under the eggs, shifting them about and raising them so as to insure aeration, then coils about them during the ten-week period that they take to hatch.

The hatchling larva, only an inch in length, has mere rudiments of limbs but is provided with three branched external gills on either side of the neck. When the period of larval life is over, these gills shrivel and disappear. As an adult the giant salamander lives well in captivity. Major Flower states that at least half-a-dozen have survived between fifty and sixty years' confinement.

The Japanese formerly fished for giant salamanders, known to them as *hansaki;* some desired them as food, and others regarded them as medicine. The method was simple. A bunch of worms or other bait was fastened to a hook wedged in the end of a bamboo. A few feet of cord was also attached to the hook but not to the bamboo, the sole purpose of which was to poke the bait into likely waterholes. Immediately a bite was felt on the bamboo, the rod was withdrawn and the fisherman hauled in the cord together with the hooked salamander. When captured, this amphibian exudes a slimy secretion with an odor resembling that of the leaves of the Japanese pepper. The secretion rapidly congeals into a gelatinous mass upon exposure to the air. In recent years the Japanese Government,

alarmed by their rapidly decreasing numbers, has sought to protect the salamanders "as a national monument," as one Japanese puts it.

ORIENTAL-SALAMANDERS

Naturally, it is to Japanese observers that we owe much of our knowledge of the breeding habits of the smaller Oriental-salamanders. These agree with the giant species in external fertilization of the eggs as well as in some other characters. But in size there is considerable difference, for few Oriental-salamanders exceed 6 inches in length, and most species are even shorter. But for the absence of scales, they might well be mistaken for lizards. The score or so of different kinds found from Sakhalin to Formosa fall into three genera, which may be separated as follows:

1. Teeth on roof of mouth forming a wavy transverse line; lungs absent; tail long and stout; claws sometimes present; range: Honshu; Shikoku; Kyushu ... *"hakone"* (*Onychodactylus japonicus*)

   Teeth on roof of mouth *usually* continued backward in a V-shaped series; lungs present 2

2. Feet with horny soles; tail strongly compressed; range: Ohdaigahara, Yamato . *"sansyono"* (*Pachypalaminus boulengeri*)

   Feet without horny soles or claws; tail neither long, cylindrical, nor strongly compressed; range: Sakhalin south to Formosa (many species) ..... *"sansyono"* (*Hynobius* spp.)

Though snow may fall on a March morning in Japan and frost frequently covers the ground, sudden changes in temperature are of common occurrence. Should it turn warmer during a rainstorm, dusky Oriental-salamanders emerge from their winter quarters and

set out in search of suitable spawning pools. The males arrive first but remain in a semitorpid state at the bottom of the pool if a cold snap supervenes. If, however, the warm weather continues for several days, the females appear and both sexes assemble in groups in the shade of a boulder or tussock of grass. Then the members of each group start swimming to and fro, rising and descending in the water, and they maintain this activity for a period of from ten to twenty hours. At the conclusion of these evolutions, each female approaches a rock, some grass stems, or perhaps the branch of a tree which is dipping into the pool. To the object selected she attaches two strings of eggs, each about 6 inches in length. Each of these spindle-shaped egg-sacks, as they are called, holds from thirty-seven to seventy eggs. Each is attached by one end only; the other end floats freely and rises or falls with changes in the water level.

Now the males swim slowly to and fro over the egg-sacks to ensure the fertilization of the jelly-enclosed ova. By conserving moisture, this jelly will protect the eggs for about two weeks should they be left stranded by failure of the rains, and drying up of ponds. If all goes well, the larvæ hatch out in due course and swim about so swiftly that they might easily be mistaken for small fish. At first these hatchlings feed on the vegetable slime growing on the stems of submerged plants, and later on insect larvæ and even the tadpoles of frogs. When their gills disappear (a sure indication that their own tadpole days are over), the little salamanders crawl from their pool to seek shelter under rocks or rotting logs in damp places near the water. At night they emerge to gorge themselves on the abundance of insect life to be found in such situations. The coloring of adult dusky Oriental-salamanders is variable, and the general pattern sufficiently similar to that of several other species to make it of little value for identification purposes.

TRUE SALAMANDERS AND NEWTS

In addition to the numerous Oriental-salamanders, there are three representatives of the SALAMANDRIDÆ to be found in Japan or

the Luchus. They are referable to two genera, which may be distinguished thus:

1. Along either flank a series of prominent knob-like glandular warts, sometimes pierced by the points of the ribs; range: Luchus ..... Anderson's salamander (*Tylotriton andersoni*)

   Flanks without a prominent series of knob-like glandular warts; range: Japan and Luchus 2 (genus *Triturus*)

2. Breast and belly red blotched with black; range: Japan ..... red-bellied newt (*Triturus pyrrhogaster*)

   Breast and belly yellow blotched with black; range: Luchus ..... yellow-bellied newt (*Triturus ensicauda*)

The primitive and bizarre-looking Anderson's salamander is an extremely warty, rough-skinned creature, blackish brown above and below except for the soles of the feet, anal opening, and a narrow line along the underside of the tail, all of which are orange. Whether the tail, which slopes to a keel-like edge both above and below, is largely reduced by absorption at the conclusion of the tadpole stage and regrown by the adult, remains to be seen, but something of the kind has been reported as occurring in a close relative on the Chinese mainland. In the Luchus it is known as *iboyamori*.

Imori is the name applied by the Japanese to the better-known red-bellied newt, so called on account of the entire under surface, including the edge of the upper lip, being red, marbled or blotched with black towards the sides; the upper aspect is uniformly blackish brown.

The skin of the male is softer and smoother than that of its mate, and when the males resort to ponds or pools in the spring their toes become elongated. In general, their habits do not differ greatly from those of their North American relatives. Fertilization of the eggs is internal, in marked contrast to the method followed by the Oriental-salamanders as described above. Also the eggs are deposited singly and attached to submerged stems or leaves. From the eggs red-

bellied newts have been raised and kept in aquaria for twenty-five years or more, good evidence of the hardiness of the species in captivity. Consequently red-bellied newts have long been a popular item with pet-store dealers.

NEW ZEALAND FROGS

A casual glance at the New Zealand frogs (there are only two species, Hochstetter's and Hamilton's, apart from a tree-frog recently introduced) will fail to reveal the fact that they are among the most primitive of all living frogs or toads. This distinction they share with the "tailed frog" of the western United States, the only other member of the family known. These three frogs all retain the muscles necessary for wagging the tails they do not have! Presumably the New Zealand frogs reached their destination from northern lands, and their ancestors along the route subsequently succumbed to climatic changes or the competition of more recent and adaptable types of frog.

Hochstetter's frog is found only on the Coromandel Peninsula of North Island, and Hamilton's frog only on Stephen Island. In neither locality are pools or streams to be found but frequent sea mists provide a sufficiently damp climate. Hamilton's frogs, which bear a superficial resemblance to the common wood frogs of North America, were found by Dr. and Mrs. F. N. Blanchard crouching in holes beneath boulders on a rock-strewn slope near the summit of Stephen's Island. Doubtless their breeding habits are similar to those of Hochstetter's frog, which lays its eggs in holes in the ground. In the absence of water each tadpole develops within its own egg-capsule. In due course legs appear, and when the egg hatches, about a month after it was laid, a perfectly formed little frog hops out into the world.

DISK-TONGUED TOADS AND FROGS

In contrast to such strictly terrestrial frogs as these New Zealand species, we find both Pacific members of the next family thoroughly aquatic. Quite apart from their distinctive ranges, the two kinds of

disk-tongued amphibians found on Pacific islands are readily separated.

Fingers without web; belly red, handsomely marbled or blotched with black; range: Tsushima; Quelpart Island, and adjacent mainland	Oriental fire-bellied toad (*Bombina orientalis*)
Fingers two-thirds webbed; belly whitish, neither marbled nor blotched with black; range: Busuanga, Calamianes, Philippines ..	Busuanga disk-tongued frog (*Barbourula busuangensis*)

This raises the question as to what constitutes a toad and what a frog. The names arose in northern Europe where agile, leaping, moist-skinned frogs were readily separated from the slow, hopping, rough-skinned toads. Even within the limits of the toad family (BUFONIDÆ) itself, however, the distinction breaks down, for in the tropics are to be found a few smooth-skinned tree-climbing toads. In North America the warty skins of certain tree-frogs (HYLIDÆ) have led to their owners being called tree-toads, a perfectly reasonable application. Even some of the true frogs (RANIDÆ) are somewhat squat and warty. So, though we cling to the terms frog and toad and they have a certain significance, there are many tail-less amphibians which might just as well be called by either name.

By whatever name we call it, there should be no difficulty in recognizing a fire-bellied toad by its black-mottled, bright red underside. The upper surface, except for the tips of fingers and toes which are red, varies from dull olive to bright green, more or less handsomely spotted with black. The length may be 1½ to 1¾ inches. So closely does the Oriental fire-bellied toad resemble one of its European relatives that for a long time the two species were thought to be one. Whether its bright coloring is useful to the Oriental toad defensively, as is the case with its European relative, appears not to have been recorded.

Like all amphibians dwelling in northern climates, fire-bellied

toads escape the rigors of the winter months by concealing themselves underground, either beneath stones or at depths where the winter frosts are unlikely to reach them. With the return of spring, the toads emerge and set out in search of suitable breeding pools. If intercepted and molested during the journey, the European fire-bellied toad undergoes various strange contortions. These include bending of the spine concavely so as to raise the head and hind-quarters, then bringing the hind limbs over the back so as to display the startling coloration of their undersides, and similarly bringing the forelimbs over the head to show their red underside; the "hands" are pressed over the eyes as if to shut out the sight of its enemy.

The toad is then said to remain motionless "feigning death," while displaying its warning colors. For frequently, though by no means invariably, red and black, or yellow and black, in the animal world denote the possession of venom-conducting stings or fangs, or else accompany distasteful or poisonous secretions. In the case of the fire-bellied toad it is the latter, for when the toad is picked up, its skin glands exude a white froth. This froth is a powerful irritant to mucous membranes and is calculated to deter a predatory animal from mouthing one of these toads. If a person looks into a bag of freshly-caught fire-bellied toads, it is sufficient to induce fits of sneezing and to start the tears flowing. Once a frog-eating animal has suffered the discomforts resulting from seizing a fire-bellied toad, it is unlikely to repeat the attempt next time it meets one, at least if reminded in time by the toad's antics and display of the danger signal.

As already remarked, the Oriental fire-bellied toad spends most of its time in the water, where it likes to rest with only the nose and eyes showing above the surface. At the same time, if disturbed, the toad spreads its limbs in readiness to dive and seek shelter in the mud or vegetation at the bottom of the pond. Pairing takes place in the water. To facilitate it, the males develop rough brownish pads on the forearm, on the three innermost "fingers," and on the site of where a "thumb" should be. In addition, the entire forearm of the male thickens so that during the breeding season there is no difficulty in distinguishing the sexes. Spawning follows the usual pattern; the

eggs, probably adhering to leaves or stems of the pond weeds, are laid in clusters.

Though chiefly of interest to professional zoologists, the Busuanga disk-tongued frog merits brief mention if only on account of the stir made by its discovery in 1923. The occurrence of a member of this family in the Philippines was not only totally unexpected, but the generic distinctiveness of the frog lent support to arguments for long separation of the Calamianes Islands. The frog found by Dr. E. H. Taylor in a small stream on the southern end of Busuanga, remained for nearly twenty years the only example known. More recently Dr. A. W. Herre visited Busuanga and not only captured an occasional disk-tongued frog in the lowlands, but found that they were relatively common in the uplands at an altitude of about 600 feet. There they lived in a small brook above the mine dam a few miles beyond San Nicolas. Adult frogs, which may be as much as 3½ inches in length of head and body, are almost uniform brownish above and cream-colored below except for the dusky brownish throat.

TOAD–FROGS

The family (PELOBATIDÆ), which includes the spade-footed toads of the United States, has a dozen species in the Philippines, Borneo, and Dutch East Indies, but none in New Guinea. The three genera to which these frogs belong can be separated on the shape of the pupil, not always easy to determine if it is dilated.

1.	Pupil vertical; range: Philippines southwest to Dutch East Indies	nose-horned frog, etc. (*Megophrys*)
	Pupil not vertical	2
2.	Pupil round; range: Mount Kinabalu, northern Borneo	slim-armed frogs (*Leptobrachella*)
	Pupil horizontal; range: Natuna Island, Dutch East Indies	Natuna Island frog (*Nesobia natunæ*)

To the genus *Megophrys* are referred all but three of these Pacific pelobatids. Many of the members of this group present a strange appearance. In most of them the skin of the head adheres to the skull, while in some the skin on the back is reenforced by minute deposits of bone. There is no web between the fingers and often none between the toes, though in some species there may be a little. Adults range from about 1½ to nearly 5 inches in length of head and body. The largest species is the quaint-looking nose-horned frog (fig. 63), which has not only a flexible prolongation of the snout but has each upraised eyelid prolonged to form a large, skinny, pointed "horn." Scattered in irregular fashion over the smooth-skinned back are a few jet-black warts. The highly variable coloration renders the frog inconspicuous; in fact, it seems to be just another dead leaf among the many real ones carpeting the forest floor. The upper side ranges from shades of pale buff to olive-brown, with frequently a dark Y-shaped marking on the back of the head and a black bar below each eye; the undersurface is cream-colored, extensively blotched with brown.

Among the islands, the nose-horned frog has been reported from Borneo, Natuna, and Sumatra. On the last island they are so plentiful at certain seasons that the night air resounds with their ringing, anvil-clanging calls of *kang kang*. Little has been recorded of their habits, but males of other species are said to emit a shrill cry when picked up and at the same time to gape widely as if about to bite.

The tadpoles of this genus are interesting on account of the extensive development of the lips to form a funnel, which has been compared to an umbrella blown inside out. With this apparatus applied to the surface of the water, its inner aspect corrugated to act as a strainer, the pollywogs suck in water so as to nourish themselves on the minute plants and animals it contains. Some believe that the funnel, by setting up surface tension, supports the tadpole. Whether it actually serves a double purpose seems debatable.

TOADS

Anyone familiar with the common toads of North America should have little difficulty in recognizing as toads their close relatives (of the same genus, *Bufo*) which are so common in the East from Sakhalin to the Indies. They appear again in the Solomons, Marianas and Hawaiian Islands, where they have been introduced to combat insect pests. These they capture by a quick movement of the sticky tongue whose hind portion is thrown on the hapless insect, the forward part being attached to the floor of the mouth at the front. Feeding takes place in the evening or at night, for toads like to hide away during the day and emerge at dusk. An exception to this general rule occurs during heavy rainstorms, for at such times toads may be found hopping about in daylight.

This is especially the case when the males set out in search of breeding ponds at the onset of the rainy season. For days or weeks thereafter, they set up a sonorous chorus to summon the females. Eggs, embedded in two long strings of jelly, are laid in the water where they are frequently entangled among the surface vegetation. Contact with the water causes the gelatinous coat to swell rapidly and provide the hatchling tadpoles with their first protection, and after hatching with their first meals. The growing pollywogs soon nibble at submerged weeds, and presently, becoming cadaverous, feed on the corpses of any creatures they may find. Thousands of these pollywogs absorb their tails, develop limbs, and sometimes emerge from the ponds simultaneously during a shower. Then every path and road in the vicinity may be a-hop with the tiny creatures, and give rise to fanciful stories of their having fallen with the rain.

In Borneo and Sumatra, however, are two kinds of toads (*Pseudobufo*) with strongly webbed hind feet; these two species prefer to remain in the water during their entire life. The finger-tips of a dozen others (*Pedostibes* and some *Pelophryne*) have developed disks, an adaptation to assist them in climbing about in bushes or trees as they are known to do. The following key sums up these distinctions. Ranges extending beyond the Pacific are not given.

1. Nostrils on top of snout, directed upwards; toes webbed to tips; range: Borneo and Sumatra ..... aquatic toads (*Pseudobufo*)

   Nostrils on sides of snout 2

2. Fingers free of web, their end bones straight; range: Sakhalin southwest to Sumatra east to Celebes (also in Solomons, Marianas and Hawaii) ..... ground toads (*Bufo*)

   Fingers slightly webbed, their tips sometimes dilated, their end bones T-shaped 3

3. Size large, length of head and body 2¾ to 4 inches; range: Borneo and Sumatra ..... tree-toads (*Pedostibes*)

   Size small, length of head and body at most 1½ inches; range: Philippines and Borneo ..... dwarf toads (*Pelophryne*)

SOUTHERN-FROGS

A half-dozen species of the so-called "southern-frogs," with headquarters in South America and Australia, are to be found in New Guinea or the Aru Islands. Indeed one tiny inch-long *Crinia* ranges all the way from New Guinea to South Australia, revealing a remarkable adaptability to diverse environments. Apparently it is equally at home in a mountain stream or in a muddy pool. This particular frog is highly variable in both appearance and color, for the skin may be either smooth or warty. The coloring of the upper side ranges from brown to pale gray, variegated with darker shades, while the flanks and hidden portions of the hind limbs are usually splashed with carmine, orange, or yellow.

The males call after rain, the sound resembling an insect's chirrup. The spawn, attached to some underwater object, may consist of as many as 150 eggs each surrounded by its own capsule of jelly. These eggs take approximately ten days to hatch, but three months is likely to elapse before the tadpoles become frogs. Little seems to be known of

the habits of the other species, but they are unlikely to depart greatly from the general pattern just described for *Crinia s. signifera*. Two other Papuan species extend their range southward into Australia.

Key to the Southern-frogs Inhabiting New Guinea and the Aru Islands

1.	No teeth on roof of mouth; eardrum hidden; toes without web though sometimes fringed	signet southern-frog (*Crinia s. signifera*)
	Teeth form a cross-row on roof of mouth	2
2.	Eardrum indistinct; toes with the merest indication of web	convex southern-frog (*Limnodynastes convexiusculus*)
	Eardrum perfectly distinct; toes with at least a rudiment of web	3
3.	Head much broader than long; first finger shorter than second	broad-headed southern-frog (*Lechriodus platyceps*)
	Head not broader than long; first finger as long as or longer than second	4
4.	Distance from tip of snout to eye more than 1½ times as long as the eye; first finger longer than second; range: Aru Islands	black-rumped southern-frog (*Lechriodus melanopyga*)
	Distance from tip of snout to eye less than 1½ times as long as the eye; first finger equal to, or a little shorter than, second	5
5.	A small ∧-shaped fold above shoulder blades	Fletcher's southern-frog (*Lechriodus fletcheri*)

A small ∧-shaped fold between eyes and a pair of curved, converging folds of skin along sides of back .. Papuan southern-frog (*Lechriodus papuanus*)

HYLID TREE-FROGS

Like the southern-frogs, the tree-frogs (or tree-toads) of the family Hylidæ are most numerous in South America and Australia, but unlike the southern-frogs their range extends across Asia to Europe and northern Africa. In the United States there are many species; some like the spring peeper and common tree-frog range even into Canada. Of the sixty kinds of hylid tree-frogs living on Pacific islands, more than half have been discovered during the last fifty years. Their recognition is often far from easy, but their separation into two genera is a simple matter if the eyes are examined.

Pupil vertical; range: New Guinea ..... *Nyctimystes*

Pupil horizontal; range: Japan south to Hainan; Moluccas east through New Guinea to the Solomons (introduced into New Caledonia and New Zealand) ..... *Hyla*

The genus *Nyctimystes* contains but five species; the remaining fifty-five are referred to *Hyla* which, as here understood, includes frogs both with and without teeth on the roof of the mouth. A century or so ago, and again in 1926, two species of *Hyla* were described as from Java. If the locality is correct, then it seems probable that the frogs were introduced and still more probable that they are rhacophorid tree-frogs, which so closely resemble the hylids.

Color is of little help in identification, because of the capacity for color change. For example, the emerald-green tree-frog of Australia and New Guinea, with a head and body length of 4 inches, normally has the upper parts irregularly speckled with pure white, and the undersurfaces entirely white. Those that spend the day squatting on the broad leaves of some tropical plant, soon match to perfection the particular shade of green upon which they may be resting. Other

emerald-green frogs may pass the day crowded together in the dark interior of some decaying tree. The green color of such frogs presently fades to dark brownish olive.

When one of these frogs is encountered squatting on a leaf in bright sunshine, its huge head is apt to present a ludicrous aspect of dreamy complacency. This is due, in part, to the eyes being half closed, with their pupils contracted to narrow slits. With the approach of darkness, all inertia disappears and the frog sets off in search of food. Climbing hand over hand, or taking prodigious leaps from leaf to leaf, it stalks and snaps up any small insects that may be encountered, using its hands to stuff the more troublesome ones well between the big jaws. When snails are taken, as many as half-a-dozen at a time, the shells are disgorged the following day. In this strange procedure the entire tongue and forward part of the gullet are first protruded from the mouth and then slowly withdrawn.

The call of the female is rather like a grunt, but males have a throat sac that enables them to emit a sharp crackling note. At certain times, such as at the approach of a thunderstorm, they make quite a different noise, that has been compared to a bellow. As the breeding season approaches, a rough brown patch appears on the first fingers of the male, a sexual distinction which they share with toads and some other amphibians. The eggs are laid in ponds where the spawn forms frothy floating patches. Of the breeding habits of the majority of hylid tree-frogs little is known, but it may be assumed that most of them resort to water to spawn.

RHACOPHORID TREE-FROGS

The hylid breeding habits contrast sharply with the unusual ways for ensuring the welfare of their offspring adopted by some rhacophorid tree-frogs. While both families occur from Japan to Formosa, it is the rhacophorid tree-frogs that are so abundant from the Philippines to Celebes, from which region the hylid group is apparently absent. The approximately fifty species have been grouped in two genera on the basis of the following characters:

Teeth on roof of mouth; toes strongly webbed ..... *Rhacophorus*

No teeth on roof of mouth; toes not or but slightly webbed *Philautus*

Separation on the basis of the presence or absence of vomerine teeth might seem illogical but for the fact that it appears to be coupled with a difference in size (*Rhacophorus* usually large, *Philautus* moderate or small), as well as in breeding habits.

As representative of the *Rhacophorus* group one might cite Schlegel's tree-frog of Japan. From mid-April to June the bright green females and their darker and smaller mates congregate in bushes at the edges of swampy pools or rice fields. When ready to breed, the female, descending from the bush, utilizes the spade-like tubercle on each hind foot to dig herself into the mound or muddy bank at the water's edge. There, a few inches below the surface, accompanied by the male, she forms a chamber 5 or 6 inches in length by 4 or 5 in height. The passage by which they enter is said to be choked by the displaced soil. In this cavity the eggs are laid, and with them a quantity of gelatinous fluid. As the eggs are extruded, the female energetically proceeds to trample the fluid with her hind feet, and keeps on doing so until the frothy mass assumes the appearance and proportions of a cream-colored meringue measuring about 2 by 4 inches. When after an hour or two the weary frog ceases her labors, the outer surface of the sticky mass hardens. Instead of returning the way they came, the frog and her consort are said to escape from the nest chamber by tunneling downward toward the water. After an interval of four to five days, the tadpoles hatch and start feeding on their albuminous prison, deriving oxygen through their gills from the air bubbles imprisoned by the mother frog's activities. As the polliwogs grow, they form a seething mass in fluid which has been resolved from the nest material. Altogether it takes about eight days from the time they first hatch until the tadpoles have so eaten away their nest that the thin outer crust collapses. This results in the well-grown polliwogs being carried with the escaping fluid down the tunnel into the water where they continue their development along normal lines.

Higher in the mountains of Honshu occurs a closely related species (fig. 65) which has improved on this method. Instead of excavating a chamber, the *mori-aogaeru*, as it is called in Japanese, makes the meringue on sprays of branches of bushes or trees (fig. 66) overhanging the water. In this case when the weight of tadpoles and fluid becomes too heavy, the lower portion of the meringue breaks away and plunges the polliwogs directly into the pool.

On the other hand, we find the little frogs of the genus *Philautus* spawning in the water retained by various plants. Mjöberg's frog was found by its discoverer laying eggs in the pitchers of a pitcher-plant growing on Mount Murud in Borneo. Hazel's frog was apparently breeding in water held by the axil of a particular species of hemp (*abacá*), when found on Canlaon Volcano in the Philippines by Dr. E. H. Taylor. Taylor remarks on the diverse coloring of the species, in which scarcely two individual frogs are alike. In varying degrees this is so characteristic of many amphibians that I have avoided giving color descriptions, which, if brief, might be misleading.

ORDINARY FROGS

A breeding habit somewhat similar to that of *Philautus* is suspected for the Nicobar frog, for spawn thought to be that of the Nicobar frog was found in water held by the axils of the Nipa palm (*Nipa fruticans*) at Batavia. In South Celebes M. A. Smith discovered that the Palawan frog spread its eggs over broad leaves or on shady rocks overhanging the water, into which the wriggling tadpoles dropped after freeing themselves from the egg capsule. In the Solomons the rear-toothed frog, with a head and body length of 5 inches, deposits its eggs in rock crevices near running water. Within each egg, when found, was a fully formed frog with short forelegs and long hind ones. The hind legs were used to such good purpose that when H. B. Guppy, discoverer of the species, ruptured a capsule, the hatchling leaped away before he could catch it.

In most instances when development takes place within the egg, the latter is of large size and relatively few eggs are laid. Con-

versely, when spawn is deposited in ponds or brooks, there is a larger number of eggs. As examples of such pond-spawning species one might mention the bullfrog, leopard frog, and wood frog of North America, all of which are members of the genus *Rana*. It is the more surprising to learn that the three frogs mentioned in the preceding paragraph are also members of this genus. However, in the Orient one must be prepared for surprises, and we find the tadpoles of yet another *Rana*, the crab-eating frog, living in quite salty water. The adult frogs are known to frequent the brackish water of estuaries and even to jump into the sea and swim ashore without any apparent ill effect.

By no means all the ordinary frogs of the Pacific belong to the typical genus (*Rana*); in fact, a key to the various genera would be too long for inclusion here. One strange-looking species of the Solomon Islands, Günther's toothed frog, has teeth in both upper and lower jaws which it uses to good purpose. Both color and markings vary to match the frog's surroundings and help to render it inconspicuous. With a piece of skin projecting from the tip of its snout, and a triangular, horn-like flap of skin above each eye, this frog bears considerable resemblance to the quite unrelated nose-horned frog (fig. 63) of the East Indies. Fringes of skin are to be found on both forearms and feet, and the skin of the back is often raised in weals or warts.

NARROW-MOUTHED FROGS

The warts and skin ridges of amphibians are often glandular, and among the narrow-mouthed frogs are some species whose skin glands exude secretions of a poisonous nature. So poisonous are the skin secretions of the groin-spot frog of the Philippines and East Indies, that if this frog is placed in a bag with other frogs its exudations will kill them. To anyone interested in strange or unusual breeding habits, no family is more likely to repay study than is that of the narrow-mouthed frogs. As suggested by the name, some—though by no means all—of these frogs have a narrow gape. This is related to

their diet, which in many instances is restricted to ants or to termites ("white ants"). Though all but two Bornean species and one New Guinean frog lack teeth, many have a compensatory arrangement of the palate, on which the skin may be raised to form one or more hard and serrated cross folds. A great many narrow-mouthed frogs are burrowers and have plump bodies (fig. 69); others again are slender, often with fingers and toes that terminate in little disks, which assist in climbing.

Among these disk-bearing species are three New Guinean frogs, belonging to as many different genera (*Asterophrys*, *Cophixalus*, and *Oreophryne*), from whose eggs the tadpole never emerges, for while still imprisoned it transforms into a frog before rupturing the envelope. The eggs in each case are united in a chain by a gelatinous cord. Largest of the three are the eggs of the robust frog, for they measure about ¼ inch in diameter. Seventeen of these eggs were found in a stump where they were being guarded by a male frog. In the case of Biró's frog, the eggs were *allegedly* deposited in water, but the tadpole, like that of the robust frog, lacks gills and receives oxygen through its large and leaf-like, non-muscular tail. Egg-strings, apparently deposited by a yellow frog, were found in a hole in the tuber of a climbing plant. The batch in this case consisted of from ten to twenty eggs.

BOURBON TOAD

Not all members of the family have such habits. Perhaps most of them follow what might be called "the normal procedure," but the life histories of the majority of narrow-mouthed frogs await a describer. Much the same might be said of a rough-skinned and warty little amphibian that has lately become important to those who seriously study frogs. Long-legged, though little more than an inch in length of head and body, its truncated snout and head bear so strong a resemblance to those of the true toads that it has been classified with them for nearly a century. Ten years ago, however, dissections by D. Dwight Davis revealed that in reality it was an East Asiatic

representative of a South American family. Perhaps further anatomical studies will show that other small Bornean and Sumatran toads accredited to *Bufo* should also be transferred to the ATELOPODIDÆ. All of which goes to prove how much remains to be discovered about the amphibians of the Pacific.

13

Suggestions for Safe Shipment of Living Reptiles

In tropical camps on lines of communication or in other quarters of a semi-permanent nature, it is probable that a few soldiers will have succumbed to native salesmanship and endeavor to keep as pets some creatures of the wild. Generally these are of the monkey tribe or parrot family, but occasionally stranger animals are brought in. Only too frequently they perish miserably, on account of their new owner's ignorance of their requirements as to food or other matters. I recall, for example, a sergeant solicitously offering bread-crumbs to a swallow with a broken wing! Unless very unobservant, he must have seen swallows hawking for insects in his homeland; apparently it never occurred to him that he had not seen them picking up crumbs.

It is in the hope of saving captive reptiles from unnecessary suffering that the following suggestions are offered, not with the object of encouraging anyone in the attempt to keep or transport such pets. This is difficult enough under any circumstances, and doubly so under service conditions.

The vital importance of shade and moisture to most reptiles is not generally realized by those who think of them only as creatures which delight to bask in the sun. In a wild state, however, the basking reptile seeks shelter as soon as it has absorbed sufficient warmth for comfort; if unable to do so, it may die an agonizing death. To be exposed to the continuous glare of a tropical day without hope of escape must be especially trying to snakes with their lidless eyes. Cages, therefore, should be provided with ample cover beneath which the occupant can take refuge, even though it chooses to remain hidden much of the time.

Provision should also be made for circulation of air by having apertures covered with gauze screening in either end, or at back and top of the cage. For small reptiles an improvised cage with glass front can be made by having a pane of glass sliding along grooves and into a grooved end. Grooved strips for this purpose can be obtained by cutting an inch-wide strip from the grooved side of a board. Glass is inadvisable and wire mosquito gauze will have to take its place when it comes to getting the reptiles home, unless the owner is traveling with his proteges and able personally to supervise their welfare. The owner should endeavor to visualize and provide for every contingency to which the animals may be subjected; much will depend on his foresight, good sense, and ingenuity. Only as a supplement are the following suggestions offered regarding arrangements for shipment. These are best considered in relation to the type of reptile which it is proposed to transport.

TORTOISES

Of all reptiles, probably land tortoises are the hardiest travelers, with turtles a close second. Both can be placed in oblong boxes which are shallow enough to prevent the reptiles piling on top of each other. A thick layer of soft dry grass should be spread in the bottom of the box to counteract possible sliding to and fro in case rough weather is encountered. This bedding is likely to become fouled and should be changed when necessary; otherwise flies will be attracted and will pester the tortoises, even laying eggs upon them with unfortunate results. In the absence of grass, excelsior can be used; wet sacking might be best for freshwater turtles.

Even land tortoises show signs of distress when subjected to unaccustomed heat. On one occasion when steaming through the Red Sea, my tortoises lost their appetite, which improved rapidly when the reptiles were transferred daily from their cage to a galvanized bath of water. There I left them floating, apparently contentedly, during the hottest noonday hours with the result that they quickly recovered their normal hearty appetites. Under natural conditions

tortoises feed daily, and though they can fast, and may be permitted to do so for a few weeks without ill effects, fasting is apt to become a habit. Some idea of the appropriate food for each species can be gained from the preceding pages after ascertaining to which group or groups they belong. Shredded scraps of raw meat dangling from a pair of forceps may be offered to the carnivorous turtles and terrapins. Tortoises should be fed on cabbage, lettuce, tomatoes, bananas, etc.; in an emergency I discovered that they liked bread and jam.

It has been said that tortoises feed better if given no water. This is contrary to my own experience, for they are thirsty creatures and will drink deeply if presented with a pan of water, though this should not be left in their box. On a long voyage these reptiles are likely to benefit if taken from their cage and given the opportunity to exercise on deck. The lid of their box may be hinged for easy access and padlocked to foil inquisitive people. If the lid is composed of well-separated strips of wood, the sides may be solid with a few augur holes in the ends to allow the air to circulate. When the box is being carried in a deck shelter, the solid sides can be turned towards any prevailing wind so that the turtles are not subjected to a draft which will give them colds.

CROCODILES AND GARIALS

Large crocodiles must be individually crated and care taken that the slats are securely fastened and capable of withstanding considerable pressure. More than once crocodiles have escaped on shipboard and been found wandering about, to the consternation of their fellow passengers. For the protection of those who have to handle the crate, the slats at the head end should be covered with chicken wire to preclude the possibility of anyone being bitten. Some arrangement will have to be made for feeding fish or meat to the reptile if the voyage is likely to be of several months' duration. Large crocodiles should be hosed twice a day, for in their scaly armor and cramped quarters they are likely to feel the heat. Consideration should also be

given to affording protection for crocodiles from those thoughtless and stupid people who cannot refrain from prodding a helpless captive to see its reaction.

LIZARDS

If small crocodiles and the water-loving larger lizards can be provided with a deep pan of water into which they can crawl but cannot upset, so much the better. Both crocodiles and monitors will eat slender strips of meat, and most monitors like raw eggs. Gauze screening on the cages of such big lizards, if covering a large area, will require strengthening by having chicken wire nailed over it *outside*. Wire netting alone is to be avoided, for the lizards will endeavor to thrust their heads through with such persistency that, even if they fail to break a strand, they develop raw places which may become septic.

Gauze screening is satisfactory for boxes containing smaller lizards provided there are no rough edges left on the inside. If the lizards are tree- or shrub-dwellers, branches to which they can cling should be firmly wedged into their cage, in addition to a layer of moss or soft grass on the floor. If drops of water are freely sprinkled on the branches each morning, they will be taken up by the tongues of these arboreal lizards which are accustomed to drinking from dew or raindrops. Most of these lizards are insect-eaters and cannot safely go without food for more than a couple of weeks. Feeding them presents something of a problem. It is true that ants and cockroaches may be found on some ships, but certain lizards refuse ants and others quickly tire of cockroaches, as if an exclusive diet of them disagreed with the lizard. In port flies may be attracted to a piece of bad meat hung inside the cage close to the door, which is left open wide enough to admit a fly but not enough to permit the lizards to escape. Sometimes it may be possible to augment the ship's diet by going ashore and sweeping the low vegetation with an insect net. By this means a rich variety of insect life may be secured, possibly sufficient to last a week.

SNAKES

Some of the small and slender tree-snakes probably travel best in cages plentifully supplied with rigid branches about which they can entwine. But snakes are more adept at escaping than are most animals, and for voyages of less than two weeks' duration some people prefer to pack them more securely. This can be done by placing them in cotton bags (pillow slips will do) and tying the open end securely. While the material of which the bags are made should not be so closely woven as to exclude air, it is essential to examine all seams critically and to look for holes; if you fail to find them, the snake certainly will not. Each bag should bear a tag on which the contents are listed; this precaution is doubly important where poisonous snakes are concerned. In particular, spitting cobras should be clearly labeled as such. The recipient of a shipment will not be protected if the labels are inadvertently transposed, as happened recently when a venomous species was received labeled harmless! Generally it is unwise to put more than two snakes in a bag together, in case one should die. The bags, well separated, should be placed in layers of excelsior in an airy box with the openings covered with gauze *outside* as an added safeguard against escape. Packed in this manner, snakes do best if kept at a temperature low enough to insure torpid inactivity. Should the box be placed in a hot and stuffy ship's hold the snakes may succumb, as moisture and air are essential to their well-being. Snakes drink a good deal, and if accompanied by their owner it would be well to remove them from their bags once a fortnight and give them water. Food can be dispensed with for several months if the reptiles were well fed before starting on their journey.

When pythons and other large snakes are placed loose in a wooden box they invariably run their snouts to and fro, especially against gauze and wire netting, in search of an exit. This ceaseless rubbing removes scales and skin, so that septic sores result which may ultimately cause death. For such big snakes, burlap bags are best. Alternatively I have successfully shipped a python from central Africa in a shallow box, 3 feet by 2 feet by 1 foot deep, with the inner sur-

faces padded with two thicknesses of sacking overlying excelsior. Once a fortnight the python was removed from its box and allowed to drink and soak for an hour in a galvanized bath over which some sacking was draped. During the journey of two months' duration the 12-foot snake sloughed its scarf skin and arrived at its destination in splendid condition.

SALAMANDERS, FROGS, ETC.

Salamanders, frogs, toads, and their allies are so susceptible to changes in temperature that anyone without previous experience is unlikely to have much success in transporting them. *They must be kept damp* during the entire voyage. Failure to provide them with moisture for even a short time will have fatal results, for frogs breathe through their skins and suffocate if they are allowed to become dry. Certain kinds of moss are good for retaining moisture but deteriorate during a long voyage. Sponges, when thoroughly freed of salt, are excellent, and if hung beneath a small hole in the lid of the cage can be watered from time to time without opening the box at the risk of having frogs jump out. Sodden white blotting paper also retains moisture well.

When tubs, zinc-lined boxes, or large cans are used, the bottom should be covered with water to a depth that permits the frogs to sit with their heads out of water. Avoid overcrowding; a few frogs are more likely to survive the journey than when jostled and constantly disturbed by restless companions. A common error is that of punching air-holes in a can from the outside. This leaves ragged edges inside on which the frogs are likely to injure themselves. Bullfrogs, in fact any of the larger long-legged frogs, are inclined to leap persistently against a lid regardless of the injuries sustained. If frogs of this kind are included in a shipment, it will be necessary to pad the lid of their container with sacking. Better still, dispense with a lid and have a burlap covering. As with lizards, food is the chief difficulty, for on modern ships, ants, cockroaches, and flies are often unobtainable. If at all possible take a supply of food on board—

a piece of comb from a termite's nest, pupæ of flies which will hatch out from time to time, or a quantity of mealworms.

A shipment should be timed to arrive in spring or summer. After safely surviving the hazards of a long voyage, more than one fine collection of living reptiles has succumbed in port because of cold weather. If unattended, arrangements should be made for the consignment to be met. The Zoological Society of New York will be glad to hear from, and advise, anyone who contemplates making such a shipment. It should be addressed:

The Curator of Reptiles,
The Bronx Zoo,
New York,
U. S. A.

14

Hints on Collecting Specimens When on Active Service

As we have seen, it is the existence of the larger reptiles that is menaced by commercial exploitation. There is no serious threat to the smaller species of whose habits and distribution we often know so little. The many problems concerning them can often be solved by judicious and responsible collecting.

EQUIPMENT

Naturally a certain amount of equipment will be necessary, but assuming that every ounce of it will have to be carried in a haversack, I propose recommending only the essentials. If so many directions suggest that collecting is too formidable a task, in practice it will be found that this is not really so; overcoming the few undoubted difficulties will lend fresh zest to the achievement.

On rocky or hard ground a smallish snake is apt to withdraw its head from the traditional forked stick. Therefore a ⊤-ended one which serves for both large and small snakes is preferable. You cannot carry a 4-foot stick from place to place, nor is it always easy to find just what you require in each new camp. It is best to procure 6 inches of light brass tubing with an inside diameter of about ½ inch into which the stem of the ⊤-piece can be fitted. These two items are easily carried in a haversack. On arrival in a new location it is not difficult to find 4 feet of bamboo, or a sufficiently straight stick, to fit into the other end of the ferrule.

When catching a snake, try to place your stick on its neck; if it

is traveling fast you are likely to be too far back. In such an event pause until the snake has quieted down a little, then release the pressure slightly. In all probability the snake will attempt to wriggle forwards; stop this by gently returning the pressure. After two or three abortive attempts, the reptile will go into reverse and wriggle backwards. Permit it to do so until the neck comes under your ⊤-piece, then press down, and stooping, grasp the snake's neck firmly between thumb and first finger of the left hand.

Some collectors have successfully snared small lizards by means of a horse-hair or string noose hanging from the end of a long rod. In my experience lizards are rarely willing to let one get near enough. The ideal method is to shoot them with dust shot from a .22 smooth-bore pistol or shotgun, but as this is impossible under active service conditions one is reduced to the primitive method of pouncing upon the quarry. This can best be accomplished with a pad of soft cloth held in one hand. A handkerchief will do but a larger rag is preferable. The edges of the rag can then be systematically turned back until the lizard's head is located. Grasp the neck firmly either with fingers or forceps, and then it will be safe to raise the pad. The advantage of this method lies chiefly in the fact that your specimen is less likely to suffer injury to the skin or loss of its tail, which so many geckos and skinks are apt to discard during capture.

A 6-inch forceps suffices and is useful for many things. A 9-inch pair is more cumbersome but safer if you wish to use it, instead of your fingers, for picking up small snakes.

On certain islands where lizards are abundant, they may be trapped by sinking a large can or oil drum level with the ground. In the bottom should be put some fat or odoriferous meat. Flies and other insects will be attracted by the carrion, and lizards, jumping in to seize the flies, will be unable to get out again.

The larger lizards and crocodiles may be shot with a service rifle, the latter by a bullet in the brain to prevent their regaining the river. Firing from above, one should aim at a point on a line between, but a little behind, the eyes. For freshwater turtles probably a hook and line will be necessary.

Frogs are best hunted when feeding at night. If a flashlight is shone in their eyes, they usually remain quiet while the hand that is to pounce on them moves up slowly from behind. For wholly aquatic forms a dip net is necessary. This can be made from a piece of old mosquito-bar and a length of supple bamboo or stiff wire bent in a circle and bound to a handle. In an emergency I have taken the mosquito-bar from my bed and got several natives to wade with it through a pool in which I had seen frogs.

However, some of the rarest and most interesting frogs are to be found in the most unlikely places. One of these is beneath the outer leaves of banana plants, particularly wild bananas, where they like to pass the day in the moist seclusion between leafstalk and stem. Other kinds may be found within sedges or beneath the loose bark of trees, while rotting moss-grown logs harbor quite a menagerie of frogs, lizards, and snakes. On turning over a log it is well to dig for a few inches in the spot where it lay, for many burrowing reptiles and amphibians favor such a retreat. In general, amphibians are most in evidence during the breeding season, which frequently coincides with the arrival or conclusion of the major rains.

Having caught your frog, lizard, or snake, you will need a few small cotton bags such as a 10-pound sugar bag, or larger and stouter ones if you propose hunting the bigger reptiles. If you are in difficulty, perhaps the hospital quartermaster may have some damaged pillow slips which can be repaired sufficiently for your purpose. It is just as well not to put several fragile-tailed geckos in the same bag, or through fighting they may lose their tails.

KILLING OF SPECIMENS

The simplest way to kill your captures is to put the bags in a compression-top can and sprinkle some chloroform over them. Surprisingly little of the anesthetic is necessary in a tightly closed receptacle. Since chloroform is rarely available when a column is on the move, confine your collecting at such times to the smaller species which, as already stated, are usually more important than the con-

spicuous ones, and provide yourself with one or two killing bottles such as entomologists use. They can be made up as follows:

Select a wide-mouthed bottle with a screw cap—that is to say, a bottle with an opening from 2½ to 3 inches in diameter and a height of 5 inches or more. Pack the bottom to a depth of nearly an inch with lump or powdered cyanide. As the fumes from this are exceedingly dangerous, tie a towel around your mouth and avert your face while working rapidly, preferably in the open air. Cover the cyanide with a layer of sawdust to a depth of ½ inch or more, pressing it down well with some blunt object such as the handle of a hammer. Sawdust is very necessary in the tropics to absorb excess moisture. Thoroughly mix some water and plaster of paris in a bowl to a stiff consistency just fluid enough to flow. Pour the plaster slowly over the sawdust till it is covered to a depth of about ½ inch. Assist the plaster to level off by rotating the bottle gently. Then leave the bottle, still open, in a safe and sunny spot until the plaster has thoroughly hardened, which may take half-an-hour. Replace the cap, and the bottle will be ready for use next day.

As creatures are apt to exude moisture while being anesthetized, it is advisable to cover the plaster with some crumpled newspaper or other absorbent material which can be changed from time to time. Without this precaution the plaster is apt to become soft and mushy. If you are careful to replace the cover promptly after opening, and not keep the bottle open longer than is absolutely necessary, it will continue to give off cyanide fumes for about a year. Bottles have one disadvantage: they may get broken and their dangerous contents spilled. Such an accident happened to me twice during six months as a result of my haversack coming into violent contact with the saddle. Thereafter I used a compression-top preserve can, but this had other drawbacks. In addition to not being able to see what was happening inside, I found that cyanide caused rusting and eventual corrosion of the tin in about nine months.

PRESERVATION AND PACKING OF SPECIMENS

While one killing bottle is carried in your haversack, another can travel in the kit bag that follows the column on a truck. Such an arrangement will assure you of the use of two bottles whenever held up in a camp for several days. The use of a killing bottle renders it unnecessary to inflict on hapless creatures the painful death of being dropped directly into the preservative, whether alcohol or formaldehyde.

Circumstances will probably decide which of these preservatives you employ. I found 40 per cent formaldehyde easier to procure, and it has the advantage that only a pint of the commercial product (which is 40 per cent) need be carried for every six pints of solution used. For five parts (by volume) of water must be added to every part of formaldehyde. If frogs or toads are to be preserved, it is well to let them soak for a few hours in water, then remove all slime before transferring them to the formalin. Obviously large numbers of frogs, their tissues already holding much water, are going to weaken your solution, so it may be necessary to add a dash of the original 40 per cent to prevent its strength being too much reduced. In the tropics it is advisable not to delay pickling your specimens an hour longer than necessary, for though they appear all right externally, decomposition may have begun within.

To counteract this, it is well to make an incision in the stomachs of any largish frogs and toads and certainly of all lizards; snakes should have slits made at intervals of from 3 to 6 inches, according to whether they be large or small. With snakes over a foot in length, by means of the forceps, draw the intestines out through the last slit before the vent, then sever them. Similarly, through the first cut behind the throat, take hold of and then sever the gullet and windpipe. By pulling steadily you can now remove the whole of the snake's internal organs between these points. This results in better preservation and using up less of the probably precious preservative. While the point of a pocket-knife blade will suffice for puncturing specimens, a pair of very small, sharp-pointed scissors will be found

even better—in fact, essential for making neat slits or for severing the viscera.

Above all, *do not overcrowd your specimens,* to which the preservative should have free access for at least two weeks. Museums often have to discard decomposed reptiles because amateur collectors, eager for quantity rather than quality, have crammed the pickle bottle or other receptacle so full that there is insufficient preservative to accomplish the task, and what there is cannot reach to every part of each specimen.

A fault in the opposite direction is to let a few things travel in a container so large that they wash to and fro. This results in the scales of the reptiles and the skin of the frogs being rubbed off, with consequent ruin of the specimen for study purposes. When forced to travel before the expiration of the fortnight essential for ideal fixation of the material, in order to prevent friction wrap your specimens loosely in some light cotton such as cheesecloth. At the end of the two weeks all but the very largest things may be permanently wrapped in cloth and tied up in small bundles of half-a-dozen or more. After a month or any time thereafter, it is safe to pack such sodden bundles in an airtight can almost without fluid, and mail them home.

It is well to remember that formalin rusts cans rapidly. As the rust will stain specimens even through a few layers of cotton, each can should be lined with several thicknesses of cloth or newspaper. Under certain circumstances it may be better to transfer the contents of several small cans to a four-gallon gasoline drum. In the event of their not entirely filling the drum, add excelsior or stiff springy grass to prevent them rattling about. The journey of the can or drum ought not to take more than three months, or there is a risk of spoiling. Immediately upon arrival, the contents should be soaked in water for twenty-four hours, then transferred to fresh alcohol of from 65 per cent strength (for amphibians and geckos) to 75 per cent (for other reptiles).

If alcohol is easier for you to obtain than formaldehyde, use the above strengths for specimens of moderate size. Lizards over 18

inches in length, as well as even small crocodiles and turtles, should be immersed in alcohol of full strength (95 per cent). Whatever the preservative used for turtles, it will be necessary to make long and deep slits in their necks, axilla, groin, tail, and all fleshy parts of their limbs. This applies to the limbs and tails of crocodiles and larger lizards as well. The necessity arises from turtles being so enclosed that it is difficult for any preservative to reach their innermost parts before decomposition sets in. Apart from olfactory warnings, signs of such deterioration begin with frothy exudations appearing at nose and anus, followed by a pink suffusion over the shields of the lower shell. If these warnings are allowed to go unheeded, presently all the shields will scale off the bony shell, the skin on the limbs will slip, and soon you will be only too anxious to throw away a specimen which you formerly treasured.

Preferable to the making of incisions is the repeated injection of formalin to all parts by means of a hypodermic syringe. It is unlikely, however, that such an instrument will be available.

The preservation of large crocodiles or sea turtles is a tedious business and not likely to be undertaken by those in the services. It calls for a sharp skinning knife, fine-toothed saw, hammer, a number of 4-inch nails or bamboo pegs, brush, and arsenical soap, or if that is unobtainable, then wood ash, which is but a poor and temporary substitute.

A large crocodile must be cut open from chin to tip of tail, this longitudinal cut being connected by four horizontal ones extending to the wrist or ankle of each limb. The skull should be left in place, but the eyes, brain, and every scrap of flesh must be removed from both it and the skin. Peg out the hide flesh side uppermost in a hot sun and have a tarpaulin handy if there is any likelihood of showers. Rub wood ash onto all exposed surfaces, or better still paint them with arsenical paste.

This is made by flaking 1 pound of yellow soap into a can that must never be used for anything else again. Cover the flakes with sufficient water to dissolve the soap, and add 1 pound of white arsenical powder. If ½ pound of naphthalene or camphor is available,

add this also, though it is not essential. Stir the mixture continuously while bringing to the boil over a fire in the open, keeping to windward of the poisonous fumes. After boiling, allow the mixture to settle and solidify. The can should have a compression top if it is to be carried from place to place. To use, moisten old shaving or other brush and work up sufficient soap into paste to paint the flesh surface of the object to be preserved. After using, wash your hands well, and in view of the highly poisonous nature of this soap, do not leave the specimen where any domestic animal can touch it. The tin should be buried deep where it cannot contaminate any water supply.

In preparing large turtles, the saw will be required to cut through the bony bridges which unite the lower (plastron) and the upper (carapace) shells. The former may then be cut away to facilitate removal of the flesh from the upper shell as well as from its limbs and flippers, which should be left attached to the shell. If impossible to preserve the entire animal, the head can be removed and pickled, or, after soaking in water for a day or two, be boiled and cleaned.

Up till now I have omitted any reference to the all-important subject of labeling. However certain you may feel that you will *never* forget the place and circumstances attending the capture of some specimen, it is likely to prove otherwise before your return. And if you do not return, the specimen, lacking this information, will be shorn of much of its value. Space will not permit explaining here *why* this is so; suffice it to say that for study purposes the exact locality—village or river, lake or mountain, followed by district and island—is all important. The date also is useful for, when coupled with subsequent dissection, it may shed light on the breeding season or period of æstivation. So print clearly *in pencil* on stout paper, at least the locality and date. You may wish to add a number that will correspond with a notebook in which you have recorded observations on the creature's habits. Some collectors prefer to depend solely on stout numbered tags corresponding to a list on which is recorded the locality and date, but such lists are all too frequently lost. Fold the paper to avoid defacement (formalin destroys most paper in

about six months), and wrap it up with the specimens to which it is applicable.

If such collections are mailed to the States, their declaration tag should bear the words: "Zoological specimens for scientific study; of no commercial value." The same formula is applied to packages that are too heavy for mailing and have to be shipped. Unfortunately, freighting them involves filling in numerous bills of lading, customs entries, and other formalities.

Harvard's Museum of Comparative Zoölogy will gratefully appreciate any such reptile collections, or care for them until the owner's return. They should be addressed to the Director or

Curator of Reptiles,
Museum of Comparative Zoölogy,
Harvard University,
Cambridge 38,
Massachusetts

SUMMARY OF EQUIPMENT

(a) Essential items

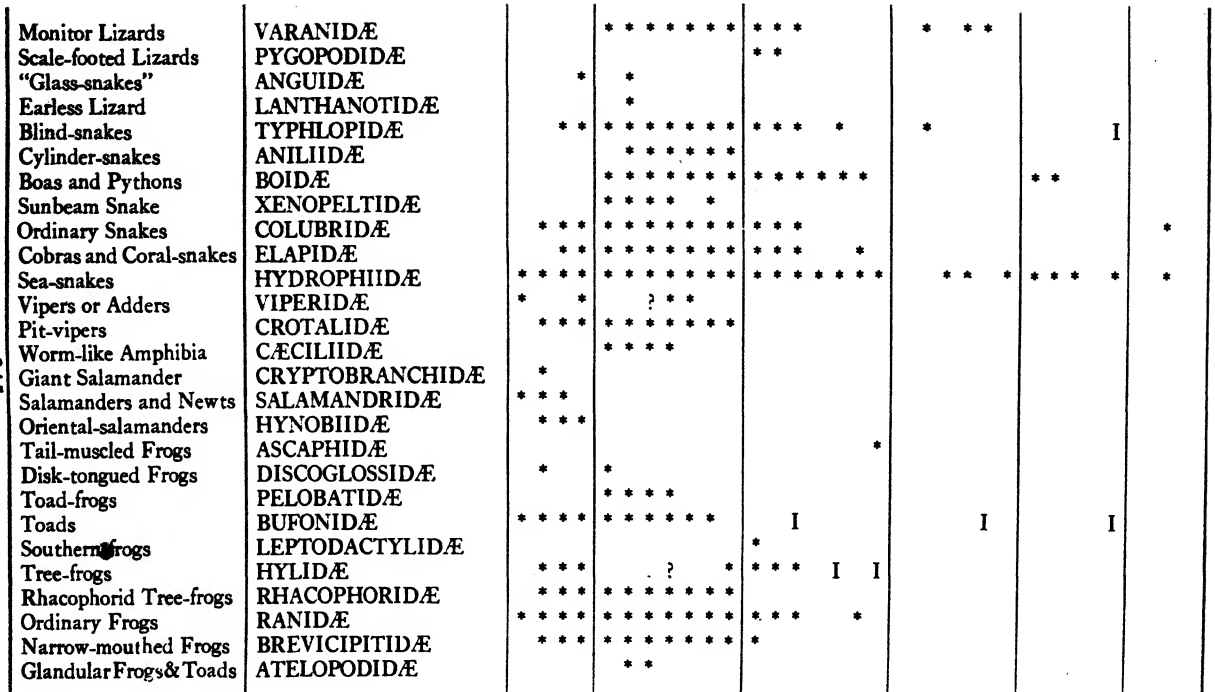
⊤-ended stick	Formaldehyde or alcohol
Ferrule for same	Cotton bags or pillow slip
Forceps, 6 or 9 inches long	Cotton rags for wrapping
Penknife	Friction-top cans for daily use
Small pointed scissors	Any suitable cans or bottles
Cyanide killing bottle	Frogging net (not essential)

(b) Necessary only if large reptiles are to be preserved

Skinning knife	Four-inch nails or pegs
Fine-toothed saw	Arsenical soap
Hammer	Hook and line (not essential)

DISTRIBUTION OF REPTILES AND AMPHIBIANS AMONG THE ISLANDS OF THE PACIFIC

Popular Name	Scientific Name of Family	North Temperate				Indonesia or Malay Subregion								Melanesia and New Zealand								Micronesia						Polynesia						South America
		Sakhalin	Japan	Luchus	Formosa	Philippines	Borneo	Sumatra	Java	Lesser Sundas	Celebes	Moluccas		New Guinea	Bismarcks	Solomons	New Hebrides	New Caledonia	Fijis	New Zealand		Bonins	Marianas	Palaus	Carolines	Marshalls	Gilberts		Samoa	Tongas	Marquesas	Societies	Hawaii		Galápagos
Tuatara	SPHENODONTIDÆ																			*														
Leathery Turtle	DERMOCHELYDIDÆ		*			*		*		*				*																				*
Sea Turtles	CHELONIIDÆ		*	*		*	*	*	*	*	*	*		*	*		*	*	*			*												*
Terrapins	EMYDIDÆ		*	*	*	*	*	*	*		*	*																						
Tortoises	TESTUDINIDÆ		*	*	*		*	*	*		*	*																						*
Snappers	CHELYDRIDÆ													*																				
Long-necked Tortoises	CHELYDIDÆ									*				*	*																			
Pitted-shelled Turtle	CARETTOCHELYDIDÆ													*																				
Soft-shelled Turtles	TRIONYCHIDÆ		*		*	*	*	*	*	*	*	*		*																				
Crocodiles and Garial	CROCODYLIDÆ					*	*	*	*	*	*	*		*	*	*	*							*										
Geckos	GEKKONIDÆ		*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*			*			*	*		*	*	*	*	*		*
Agamids	AGAMIDÆ			*	*	*	*	*	*	*	*	*		*		*			~											~					
Iguanids	IGUANIDÆ																		*											*				*
Skinks	SCINCIDÆ		*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*			*			*	*		*	*	*	*	*		-
Limbless Skinks	DIBAMIDÆ					*	*	*			*	*		*																				
True Lizards	LACERTIDÆ	*	*	*	*		*	*	*																									



I = introduced

? = record requires confirmation

Useful English Works on Oriental Herpetology

In the foregoing pages more than fifty authors are cited, but their contributions to our knowledge of Pacific reptiles and amphibians are, in most cases, to be found only in scattered articles. As these have appeared in some scores of scientific journals, many of which are difficult to obtain, I have listed below only the largest.

BARBOUR, THOMAS

1912. "A Contribution to the Zoögeography of the East Indian Islands." Mem. Mus. Comp. Zoöl., **44**, pp. 203, pls. i–viii (Museum of Comparative Zoölogy, Cambridge, Mass.).
Naturally the discoveries of the past 30 years have extended ranges and affected some of the conclusions.

BEEBE, WILLIAM

1924. "Galápagos; World's End." pp. xix + 443, figs. 1–82, col. frontispiece & pls. i–viii (G. P. Putnam's Sons. New York).
An account of the islands and their animal life with much about the reptiles.

BURT, C. E. & M. D.

1932. "Herpetological Results of the Whitney South Sea Expedition. VI." Bull. Am. Mus. Nat. Hist., **63**, pp. 461–597, figs. 1–38 (American Museum of Natural History, New York).
A technical paper included here on account of its extensive bibliography of articles dealing with particular islands.

DERANIYAGALA, P. E. P.

1939. "The Tetrapod Reptiles of Ceylon. I. Testudinates and Crocodilians." pp. xxxii + 412, figs. 1–137, pls. i–xxiv (Colombo Museum, Ceylon and Dulau Co. Ltd., London).

A technical account of the turtles and crocodiles, but with a wealth of information on habits and life histories.

KAMPEN, P. N. VAN

1923. "The Amphibia of the Indo-Australian Archipelago." pp. xii + 304, figs. 1–29 (E. J. Brill Ltd., Leiden).
A purely technical account, still useful though rapidly becoming out of date.

POPE, C. H.

1935. "The Reptiles of China; Turtles, Crocodilians, Snakes, Lizards." Natural History of Central Asia, **10**, pp. lii + 604, figs. 1–78, pls. i–xxvii, map (American Museum of Natural History, New York).
Keys to all species and a mine of information about habits; lizards are treated briefly.

1937. "Snakes Alive and How They Live." pp. xii + 238, figs. 1–28 and 30 plates of photographs (Viking Press, New York).
The best popular introduction to snakes yet published.

ROOIJ, N. E.

1915. "The Reptiles of the Indo-Australian Archipelago. I. Lacertilia, Chelonia, and Emydosauria." pp. 384, figs. 1–132 (E. J. Brill Ltd., Leiden).
A purely technical account with keys, but many of the names used are superseded.

1917. "The Reptiles of the Indo-Australian Archipelago. II. Ophidia." pp. 334, figs. 1–117 (E. J. Brill Ltd., Leiden).
A technical account of the snakes with keys, but many of the names used are superseded.

SCHMIDT, K. P.

1927. "The Reptiles of Hainan." Bull. Am. Mus. Nat. Hist., **54**, pp. 395–465, figs. 1–17, pl. xxvii (American Museum of Natural History, New York).
A list of the species without keys, and technical account of those collected by C. H. Pope in 1922–1923.

SMITH, M. A.

1926. "Monograph of the Sea-Snakes (Hydrophiidæ)." pp. xx + 130, figs. 1–35, pls. i–ii (Taylor & Francis, London).
A highly technical account of this difficult group, with keys to, and descriptions of, the sea-snakes of the world; only 3 have been described since.

1931. "The Fauna of British India. Reptilia and Amphibia. **1.** Loricata, Testudines." pp. xxviii + 185, figs. 1–42, pls. i–ii, map (Taylor & Francis, London).
A technical account of the crocodilians and tortoises with a fair amount about their life histories. Not confined to the species of India.

1935. "The Fauna of British India. Reptilia and Amphibia. **2.** Sauria." pp. xiv + 440, figs. 1–94, pl. i, map (Taylor & Francis, London).
A technical account of the lizards with scope as last.

1943. "The Fauna of British India. Reptilia and Amphibia. **3.** Serpentes." pp. xii + 583, figs. 1–166, map (Taylor & Francis, London).
A technical account of the snakes with scope as above, it contains a wealth of information brought right up to date.

STEJNEGER, LEONHARD

1907. "Herpetology of Japan and Adjacent Territory." U. S. Nat. Mus. Bull., **58**, pp. 557, figs. 1–409, pls. i–xxxv (Smithsonian Institution, Washington).
Largely outdated by subsequent discoveries, still useful however; copiously illustrated.

TAYLOR, E. H.

1921. "Amphibians and Turtles of the Philippine Islands." pp. 193, figs. 1–9, pls. i–xvii. Publ. No. 15 (Bureau of Science, Manila).
A technical account with keys and a sprinkling of life-history matter. The following papers are similar in scope.

1922. "The Snakes of the Philippine Islands." pp. 312, figs. 1–32, pls. i–xxxvii. Publ. No. 16 (Bureau of Science, Manila).

1922. "The Lizards of the Philippine Islands." pp. 269, figs. 1–53, pls. i–xxiii. Publ. No. 17 (Bureau of Science, Manila).

WALL, FRANK

1921. "The Snakes of Ceylon." pp. xxii + 581, figs. 1–98, frontispiece, map (Government Press, Colombo).
Packed with information about life histories of snakes, many of which occur also in the East Indies. A good proportion of the scientific names are superseded.

Index to, and Systematic List of, Species Mentioned